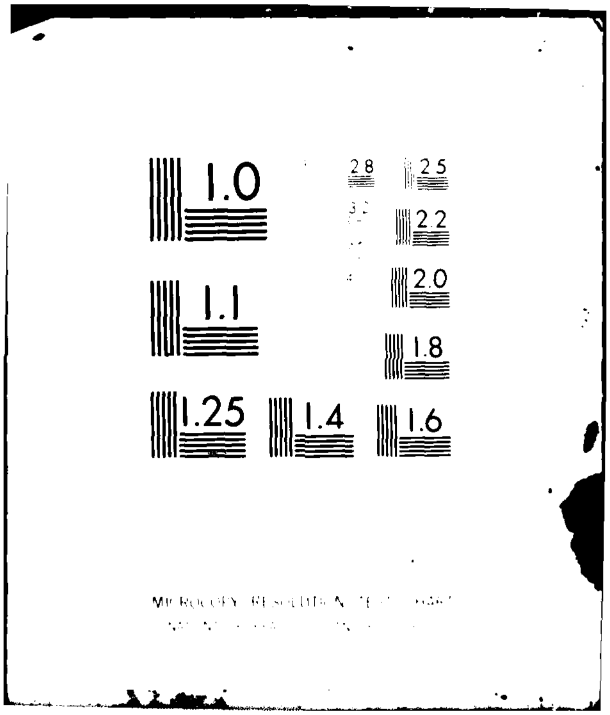
AD-A108 271 NORTHEASTERN UNIV BOSTON MASS ELECTRONICS RESEARCH LAB F/G 19/7
DESIGN OF SOUNDING ROCKET PAYLOADS.(U)
JUL 81 R L MORIN, L J O'CONNOR F19628-76-C-0152
UNCLASSIFIED AFGL-TR-81-0235 NL

1 OF 1
AD A
108271

END
DATE
FILMED
01-82
DTIC


1.0
2.8
2.5
3.2
2.2
2.0
1.1
1.8
1.25
1.4
1.6

(12) LEVEL III

AFGL-TR-81-0235

AD A108271

DESIGN OF SOUNDING ROCKET PAYLOADS

A025205

Richard L. Morin

Lawrence J. O'Connor

NORTHEASTERN UNIVERSITY
Electronics Research Laboratory
Boston, Massachusetts 02115

DTIC ELECTE DEC 9 1981 S D B

FINAL REPORT

1 May 1976 through 30 April 1981

1 July 1981

Approved for public release: distribution unlimited

Prepared for

AIR FORCE GEOPHYSICS LABORATORY

AIR FORCE SYSTEMS COMMAND

UNITED STATES AIR FORCE

HANSCOM AFB, MASSACHUSETTS 01731

DTIC FILE COPY

124500 81 12 08 229

Qualified requestors may obtain additional copies from the Defense Documentation Center. All others should apply to the National Technical Information Service.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

MIL-STD-847A
31 January 1973

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFGL-TR-81-0235	2. GOVT ACCESSION NO. AD-A108 271	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) DESIGN OF SOUNDING ROCKET PAYLOADS		5. TYPE OF REPORT & PERIOD COVERED Final - 1 May 1976-30 April 1981 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Richard L. Morin Lawrence J. O'Connor		8. CONTRACT OR GRANT NUMBER(s) F19628-76-C-0152
9. PERFORMING ORGANIZATION NAME AND ADDRESS Northeastern University Electronics Research Laboratory Boston, Massachusetts 02115		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 61102F 765904AJ
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Geophysics Laboratory Hanscom AFB, Massachusetts 01731 Contract Monitor: Edw. F. McKenna/LCR		12. REPORT DATE 1 July 1981 13. NUMBER OF PAGES 70
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Sounding Rockets, Payloads, Timers, Programmers, Power Systems, Structures, Deployment Systems, Eject Mechanisms, Diagnostics, Control Consoles, Manacle Rings

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report is a summary of work accomplished under Contract No. F19628-76-C-0152 from 1 May 1976 to 30 April 1981. Contract efforts were in the design, fabrication, testing, and launch support of sounding rocket payloads and related ground support equipment.

Specific areas of work related to this report include: payload

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

Block 20 (cont.)
structures, component packaging, deployment and eject mechanisms, diagnostic components, in-flight sequencing, power systems and control consoles. Also described are electrical and mechanical interfaces with experiments, telemetry systems, attitude control systems, recovery systems and other payload subsystems.

Accession For
NTIS GRA&I ☑
DTIC TAB ☐
Unannounced ☐
Justification

By
Distribution/
Availability Codes

Dist	Avail and/or Special
A	

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

1.0 INTRODUCTION

Summarized in this report is the work effort performed under Contract No. AF19628-76-C-0152, from 1 May 1976 to 30 April 1981. Contract No. AF19628-76-C-0152 was a continuation and extension of efforts initiated under four previous contracts - i.e., AF19(628)-4361, F19628-67-C-0223, F19628-70-C-0194, and AF19628-73-C-0152. The accomplishments of the previous four contracts can be found in References 1 through 5 of this report.

1.1 PROJECT SUMMARY

Topics in Table 1.1 can be divided into three categories: sounding rocket payloads, MSMP payloads and related investigations not related to a specific payload. The MSMP and payload A10.705-2 are continued from the previous contract. Payloads A13.020, A13.030, and A13.031 were designed, fabricated and delivered under the current contract, but field services and launch support were funded by the follow-on contract, F19628-81-C-0029.

1.2 LAUNCH SUMMARY

The launch vehicles, scientific experiments, launch sites and launch dates of the 17 payloads launched during the 60 month period are summarized in Table 1.2 of this report. Many payloads also carried other experiments to supplement the prime experiment data. Section 5.2 and 3 discuss the individual payload configurations. As indicated in Table 1.2, nine (9) different launch vehicles were used to meet the requirements of the various experimental payloads. Details of launch support provided under the contract are listed in Section 5.

TABLE 1.1

F19628-76-C-0152 Project Summary

1 June 1976 - 30 April 1981

PROJECT	PROGRAM (if applicable)	START DATE	STATUS
A24.609-1	MSMP	October 1975	Launched 10 Nov. 77
A24.609-2	MSMP	October 1975	Launched 21 May 80
A24.609-3	MSMP	October 1975	Scheduled Apr. 82
A10.705-1	N/A	May 1976	Launched 24 Sept. 77
IC719.08-1	N/A	July 1976	Launched 27 Feb. 78
A04.602	N/A	November 1976	Launched 12 Dec. 77
A08.708-1	Cluster Ion	October 1977	Launched 15 Sept. 78
A08.708-2	Cluster Ion	October 1977	Redefined (A10.802-1)
Payload Timer	N/A	January 1978	Nine Units Flown
A18.805	N/A	January 1978	Launched 7 Aug. 79
A31.702	N/A	April 1978	Launched 3 Aug. 79
A10.802-1	Solar Eclipse	March 1978	Launched 26 Feb. 79
A10.802-2	Solar Eclipse	March 1978	Launched 26 Feb. 79
A08.705-2	DMSP	July 1978	Launched 14 Aug. 79
Recovery Drop Tests	MSMP	April 1979	Complete Aug. 79
Recovery System	N/A	July 1979	One System Flown
A13.073	Energy Campaign	May 1980	Launched 16 Nov. 80
A10.901-1	Solar Proton Event	June 1980	Launched 22 Oct. 80
A10.901-2	Solar Proton Event	June 1980	Scheduled Aug. 81
A30.072	N/A	August 1979	Launched 5 Feb. 81
A13.030	Auroral - E	October 1979	Launched 6 Mar. 81
A13.031	Auroral - E	October 1979	Launched 6 Mar. 81
A13.020	Auroral - E	November 1979	Launched 6 Mar. 81
Ignition System	N/A	August 1980	Three Systems Flown
Separation System	N/A	November 1980	Four Systems Flown
A10.901-3	Solar Proton Event	June 1980	Scheduled Aug. 81

TABLE 1.2

F19628-76-C-0152 Launch Summary

1 June 1976 - 30 April 1981

PAYLOAD NUMBER	LAUNCH VEHICLE	PRIME EXPERIMENT	LAUNCH SITE	LAUNCH DATE
A24.609-1	Aries	Target Measurements	WSMR	10 Nov. 77
A24.609-2	Aries	Target Measurements	WSMR	21 May 80
A10.705-1	Paiute-Tomahawk	Neutral M. S.	WSMR	24 Sept. 77
IC719.08-1	Sergeant-Hydac	Multiple	PFRR	27 Feb. 78
A04.602	Aerobee - 170	Interferometer	WSMR	12 Dec. 77
A08.708-1	Nike-Tomahawk	Mass Spectrometer	WSMR	15 Sept. 78
A18.805	Black Brant 5C	Engineering Test	WSMR	7 Aug. 79
A31.702	Astrobee F	FWIF	WSMR	3 Aug. 79
A10.802-1	Paiute-Tomahawk	Mass Spectrometer	Red Lake	26 Feb. 79
A10.802-2	Paiute-Tomahawk	Mass Spectrometer	Red Lake	26 Feb. 79
A08.705-2	Nike-Tomahawk	Neutral M.S.	WSMR	14 Aug. 79
A13.073	Taurus-Orion	CVF Spectrometer	ARR	16 Nov. 80
A10.901-1	Paiute-Tomahawk	Mass Spectrometer	PFRR	22 Oct. 80
A30.072	Sergeant	FWIF	PFRR	5 Feb. 81
A13.030	Taurus-Orion	EPS, Photometer	PFRR	6 Mar. 81
A13.031	Taurus-Orion	EPS, Spectral	PFRR	6 Mar. 81
A13.020	Taurus-Orion	Mass Spectrometer	PFRR	6 Mar. 81

1.3 LAUNCH RESULTS

Launch results in Table 1.3 are divided into 4 categories: vehicle performance, payload operation, scientific data and recovery. Considering scientific data the primary objective, twelve (12) of the sixteen (16) launches can be considered as completely successful, three as partially successful, and no useful data was obtained from A30.072. Payload A18.805 was an engineering test and carried no scientific experiments. The "payload operation" column refers to the direct responsibilities under Contract No. AF19628-76-C-0152. As indicated, the instrument door problems on A24.609-1 was the only anomaly noted.

2.0 SOUNDING ROCKET PAYLOADS

A total of 15 sounding rocket payloads are described in the following sections. Components common to all payloads include timers, logic relays, commutators, batteries, power transfer relays, accelerometers, and signal conditioning circuits to enable monitoring of all system functions. Related ground support equipment includes payloads control consoles, test cables, launcher cables and blockhouse interface cables compatible with the particular launch facility. This contractor was also responsible for coordinating the electrical and mechanical interfaces to other payload sections.

Typically all payload components, diagnostic instrumentation, and sub-systems are checked at Northeastern. Integration and environmental tests of the overall payload are conducted at the AFGL facilities and system checks are repeated at the launch site

TABLE 1.3

F19628-76-C-0152 Launch Results

1 June 1976 - 30 April 1981

PAYLOAD NUMBER	VEHICLE PERFORMANCE	PAYLOAD OPERATION	SCIENTIFIC DATA	RECOVERY (if applicable)
A24.609-1	Below Predicted	Partial	Partial	Failure
A24.609-2	Success	Success	Success	Success
A10.705-1	Success	Success	Success	Success
IC719.08-1	Success	Success	Success	N/A
A04.602	Success	Success	Success	Success
A08.708-1	Below Predicted	Success	Partial	Failure
A18.805	Success	Success	N/A	Success
A31.702	Success	Success	Success	Success
A10.802-1	Success	Success	Success	Failure
A10.802-2	Success	Success	Success	Failure
A08.705-2	Success	Success	Partial	Success
A13.073	Success	Success	Success	N/A
A1[illegible].901-1	Success	Success	Success	Success
A30.072	Success	Success	Failure	Success
A13.030	Success	Success	Success	N/A
A13.031	Success	Success	Success	N/A
A13.020	Success	Success	Success	N/A

prior to mating with the rocket motor. Tech Data Reports describe timing sequences, telemetry formats, component calibrations and other pertinent details of the individual payloads.

2.1 A10.705-1 and A08.705-2 PAYLOAD DESCRIPTION

A neutral mass spectrometer experiment was launched on two different boost vehicles during the contract period. Also included in the 12-inch diameter payload was a telemetry section, an attitude control system and a despin/separation module. The entire payload was 118-inches long and weighed 280 lbs. In all previous mass spectrometer payload designs, the instrument was forward-looking, and the vacuum cap was removed in conjunction with a release mechanism in the 9-inch or 12-inch conical tip. The requirement for a side-viewing instrument on this payload necessitated a large (15-inches long X 120^{o}) ejectable door and an independent mechanism to release the mass spectrometer vacuum cap. This configuration allowed packaging of the support instrumentation in the stationary nosecone.

2.1.1 A10.705-1 LAUNCH DATA

The scientific objective of the A10.705-1 payload was to measure the density of thermosperic species. The measurements were coordinated with other measurements to obtain the parameters necessary for studying the structure and heating processes in the normal thermosphere.

Field operations began at White Sands Missile Range on 15 September 1977. Weather conditions postponed the scheduled launch on 23 September, but conditions were favorable the following day and the launch occured at 0615 hours MST. All vehicle and payload systems performed as predicted and useful mass spectrometer data was obtained. The payload was recovered in excellent condition later that day. Re-entry heating damaged the wiring harness in the area of the mass spectrometer door; however, no damage to the flight components was observed during post-flight checks.

2.1.2 A08-705-2 LAUNCH DATA

Expended mechanical components and mechanisms from A10.705-1 were replaced and the recovered payload was refurbished for launch on a Nike-Tomahawk vehicle. Payload A08.705-2 was included in a program with three other payloads to continue studies of the upper atmospheric thermal structure in conjunction with the DMSP satellite.

Several problems were encountered and rectified during pre-launch checks at White Sands Missile Range in early August 1979. The launch occured, as scheduled, on 14 August, at 1050 hours MDT. All support systems functioned as programmed, but the mass spectrometer lost vacuum during boost. Some useful data was received and the payload was recovered in good condition the same day.

2.2 IC719.08-1 PAYLOAD DESCRIPTION

The configuration and instrument complement of this 12-inch diameter payload was changed several times during the design phase of the program. Two cylindrical payload sections and the nosecone were eventually defined to package the twelve (12) scientific experiments and the support instrumentation. Telemetry components were packaged in a separate package, aft of the experiments.

A nosecone experiment package was ejected from the primary payload section after vehicle burn-out. This satellite had its own telemetry system and included two energy deposition scintillators (EDS) and a three-axis magnetometer system. The scientific instruments in the primary experiment section included: two electrostatic analyzers (ESA), a high altitude retarding potential analyzer (HARP), an E-field experiment package, a capacitance probe, a D.C. probe, two forward-looking photometers, a plasma frequency probe (PFP), and an EDS. This configuration required a total of eight (8) ejectable instrument doors. A second E-field experiment, including two doors for the antennas, was packaged in the support instrumentation section in order to meet the specification that it be separated from the forward E-field by 1.5 meters. Since there was no attitude control system on this payload, a three-axis attitude sensing gyro platform was included in the payload section. Due to the relatively simple timing format required, six-switch mechanical timers were used in this application.

2.2.1 IC719.08-1 LAUNCH RESULTS

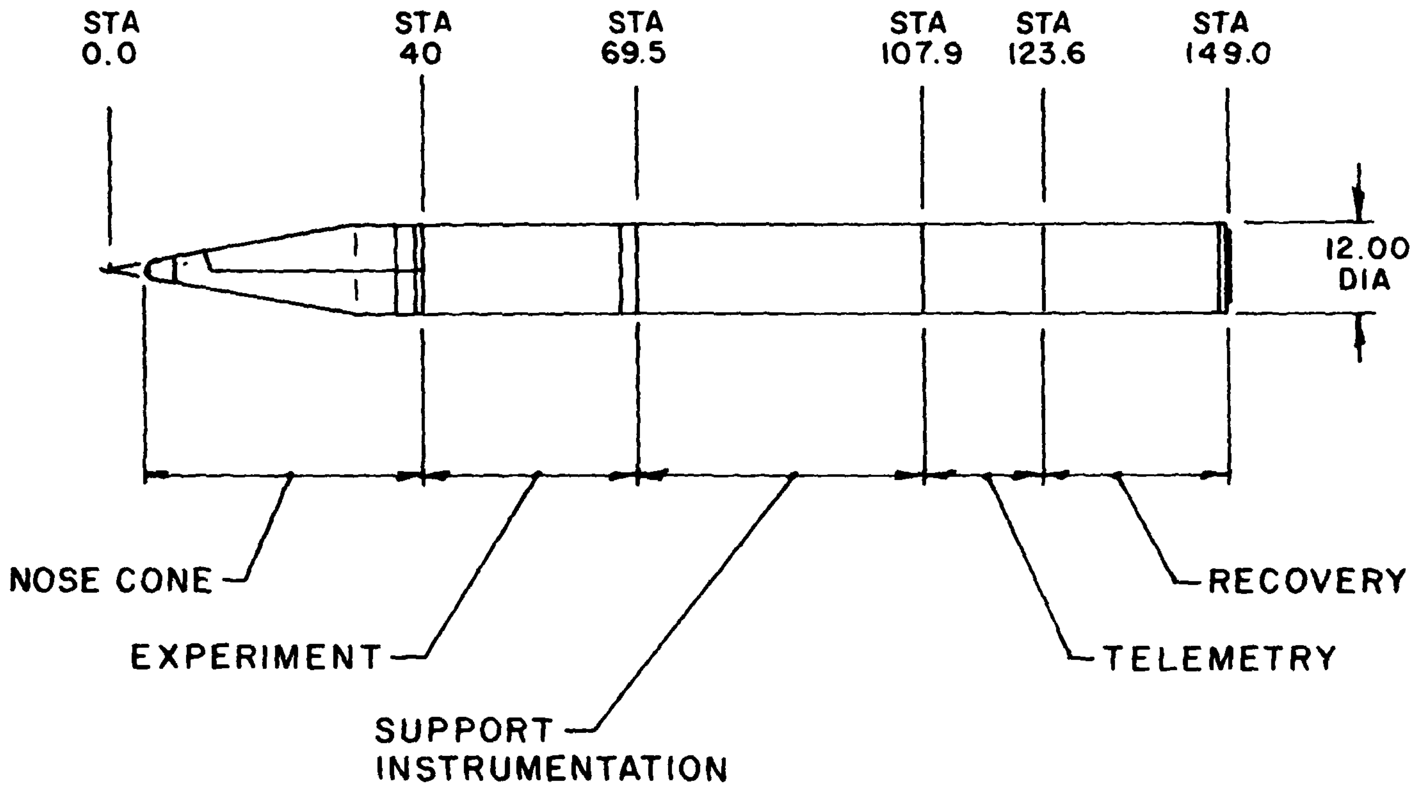
Personnel traveled to PFRR on 24 October 1977 to participate in the launch of payload IC719.08-1. Pre-launch checks were completed and the payload was installed on the launcher on 10 November. Several countdowns were conducted in the next ten days; however, a combination of atmospheric conditions and problems with both the payload and the range radar system precluded the launch. Unresolved range support troubles forced postponement of the program on 20 November.

Field operations for payload IC719.08-1 resumed at Poker Flat Research Range on 21 February 1978. The payload was re-assembled, checked and mated to the launch vehicle on 27 February. Launch criteria were met during the first coutdown on 28 February, and IC719.08-1 was launched at approximately 2200 hours, local time. All support systems performed as predicted, and data was received from both the primary payload and the ejected nosecone experiment sections. The payload was not equipped with a recovery system.

2.3 A04.602 PAYLOAD DESCRIPTION

Figure 2.1 defines the configuration of payload A04.602. The purpose of this launch was to flight-test a 10 1/2-inch diameter Michelson Interferometer. In addition to a liquid nitrogen dewar the experiment package requires an electronics box for control and signal processing, a PCM encoder, and a custom built instrument battery pack. The instrument cap mechanism presented the major mechanical design problem. Initially the system was designed using a manufactured mechanism, which included a pyrotechnic actuated pin-puller. Further investigation revealed the complete mechanism was not economically feasible in small quantities. Alternatives were investigated and a new mechanism was designed using a standard pyrotechnic device.

A three-axis MIDAS gyro platform and redundant six-function mechanical timers were included in the support instrumentation section. Additional logic was required to overcome the setting limitations of the mechanical timers. Solid state timing modules and relays were used in conjunction with the timers to provide the required four-second pulses to each of the two interferometer calibration lamps. Provisions were also included to prevent an inadvertent hang-up in the calibration mode. Calibration pulses,



PROFILE DRAWING
A04.602

FIGURE 2.1

through the timing modules, can also be initiated from the control console. An altitude switch control circuit was also added to the original timing logic in order to remove power from the experiment mirror before payload impact. The total running cycle of the timer is 300 seconds, which is inadequate for this down-leg function. In this case the timer enabled a 50,000 foot altitude switch which provides the actual power-down pulse at the desired time. A 75,000 foot altitude switch is used in conjunction with the 50,000 foot switch and relays to allow the power-down pulse only after the proper altitude sequence-- i.e. the command is not possible when the altitude switches change state on the up-leg of the trajectory.

2.3.1 A04.602 LAUNCH DATA

Pre-launch checks of payload A04.602 began at White Sands Missile Range on 5 December. Instrument problems dictated a number of wiring changes to improve sensitivity, eliminate noise problems, and increase the time of calibration pulses. Two 0.5-second to 5-second variable time delays were used to generate calibration commands to the interferometer. The sensitivity problem required an increase in the calibration interval to approximately 40 seconds (i.e. from burnout to cap eject). Replacement time delays capable of 50-second intervals were calibrated at Northeastern and shipped to WSMR on 8 December; however, further investigation of the overall timing sequence provided another alternative. Rewiring of the relay logic box enabled the cap eject command from the timer to extinguish the calibration lights coincidental with the cap function. This solution was selected for time expediency and since it maximized the calibration on time prior to cap eject.

Vertical tests were conducted with the payload mated to the Aerobee 170 vehicle on 11 December. Optical site problems delayed the scheduled 2030 hours launch on 12 December 1977; however, A04.602 was launched at 2250 hours MST. Telemetry records indicate that all support systems and diagnostic instrumentation functioned as predicted, and usable data was obtained from the interferometer. The payload was recovered in excellent condition the following day.

2.4 A08.708-1 and A08.708-2 PAYLOAD DESCRIPTION

The configuration of payloads A08.708-1 and A08.708-2 is similar to that depicted in Figure 2.4, except that the in-flight ignition module was not included. Ignition of the second-stage Tomahawk motor was accomplished through a time-delay, initiated by a launcher mounted first-motion switch. A forward looking mass spectrometer is packaged in the forward experiment housing which includes a 12-inch diameter to 9-inch diameter transition to the ejectable nosecone. Bellows actuated mechanisms were utilized to release the split nosecone and sequentially pull the mass spectrometer vacuum cap. Several tests were conducted to confirm the operation of the system in the flight configuration. An additional four-pound weight was then added to the cap pull bar, and the mechanism functioned properly. Separation of the split nosecone was observed closely during testing. The mechanism in this design is located at approximately the mid-point of the cone, and some concern was expressed that the high center of gravity may not provide a clean release from the bottom groove. Both systems functioned properly with no indication of unequal forces.

Two boom-deployed gerdien condensers (shown deployed in Figure 2.4) were the secondary experiments on these payloads. Wind tunnel tests were conducted to determine the optimum location of the deployed condensers. Test results indicated the optimum location to be 42 inches aft of the 9 inch to 12 inch diameter transition. Another constraint dictated was that the door openings for the gerdien condensers be aft of the deployed sensors. Potentiometers were also incorporated to monitor boom positions. Functional tests of the sequential door and boom operation were conducted on the AFGL spin table. Guillotine cutters were wired to the door eject mechanisms and boom release cables. Initially the gerdien section was spun up to 8 RPS, then the doors and booms were checked. Next, the doors were ejected at 1 RPS by initiating the guillotine cutters through the spin table slip rings. Finally, the guillotines were fired to release the restraint cable, and the booms were deployed, also at 1 RPS. All systems functioned as anticipated.

The task of designing and fabricating a despin module for payloads A08.708-1 and A08.708-2 was also assigned to this contract. A 4-inch long payload section was defined, including redundant guillotine cutters which are actuated by the payload timer. Provisions were incorporated to enable changes to the cable length and/or the size of the weights, allowing this design to be used in future applications.

2.4.1 A08.708-1 and A08.708-2 LAUNCH DATA

Personnel arrived at WSMR in September 1978 to begin assembly and checkout of payloads A08.708-1 and A08.708-2. Range supported horizontal checks were conducted from the LC-37 assembly area on 13 and 14 September. All systems functioned normally on both payloads. Payload A08.708-1 was then completely assembled and mated to the booster in the vehicle assembly building. On 15 September A08.708-1 was transported to the 350 launch pad, and a successful vertical check was completed 3 hours before the scheduled launch time. Payload A08.708-1 was launched, on schedule, at 1500 hours MDT, on 15 September. Vehicle burns, despin, nosecone separation, and gerdian deployment occurred as programmed, and all signals were normal; however, at T+63.5 seconds the in-flight telemetry calibrator inadvertently hung-up in the calibrate mode resulting in most data channels remaining at the upper band-edge for the remainder of the flight. Data was received only from the commutator channel and the two mass spectrometer channels not included in the in-flight calibrator scheme. Useful mass spectrometer data was received, and the commutator monitors revealed no other abnormalities.

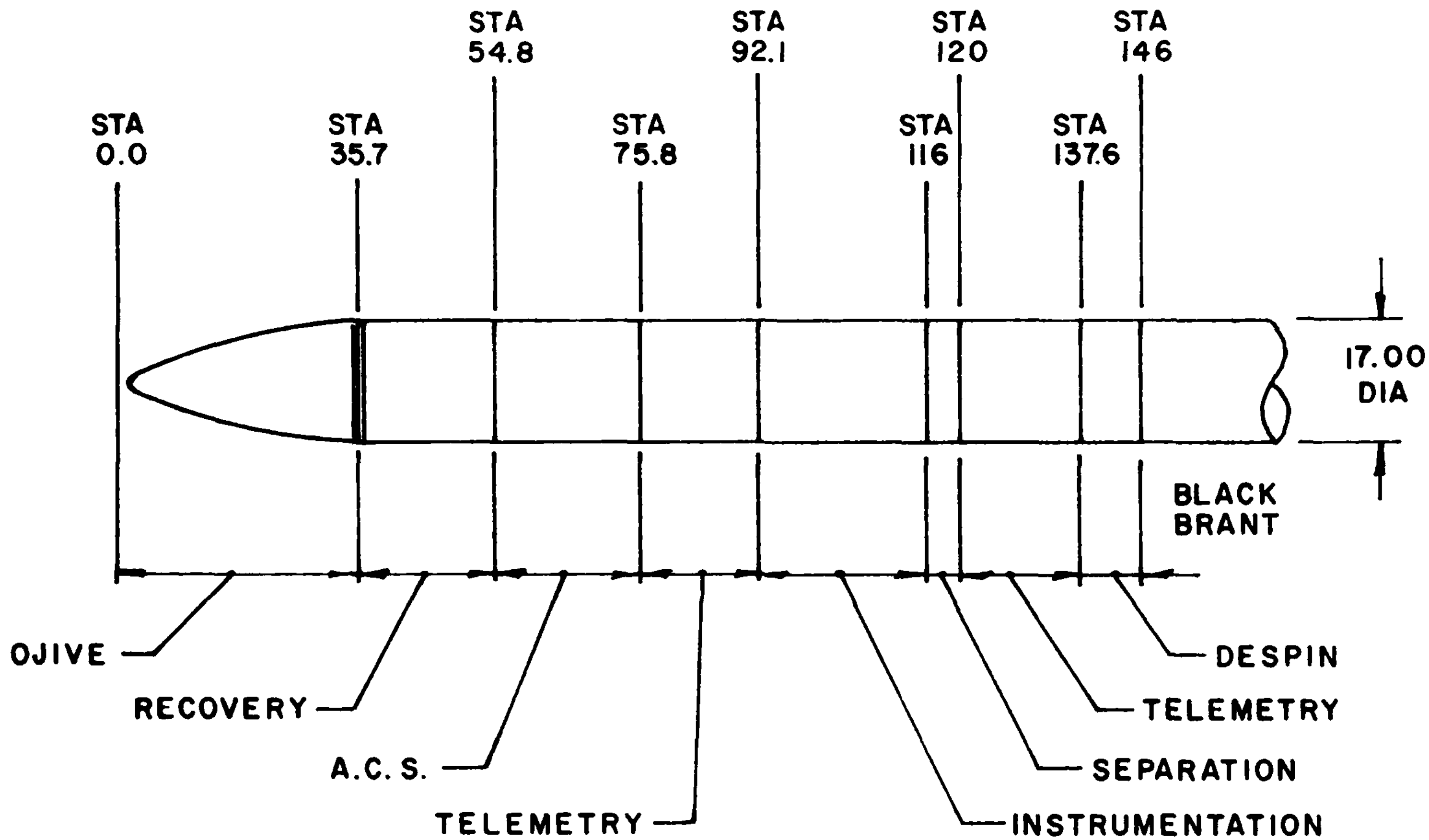
Two other problems during the A08.708-1 flight were related, in part, to a lower-than-predicted trajectory of the Nike-Tomahawk. Data indicated an apogee of 114 km., which was 14 km. below predicted. The pitch-up maneuver command to the attitude control system occurred as programmed at T+290 seconds; however, the control system was unable to perform due to the low altitude of the payload. Secondly, the recovery system failed, resulting in no salvageable components or structures, with the exception of the despin module.

A08.708-2 was scheduled for launch on the evening of 15 September, but was delayed to further investigate the A08.708-1 failure. Radar and diagnostic instrumentation data from the flight, and review of the trajectory program did not sufficiently explain the problem; therefore, the second launch was postponed indefinitely.

2.5 A18.805 PAYLOAD DEFINITION

As indicated in Figure 2.2 payload A18.805 is comprised of two independent payload systems, one of which remains with the spent booster after separation. The objective of this engineering test was to determine post-burnout thrust characteristics of a solid propellant rocket motor. Contamination of sensors by rocket outgassing has been observed by many sounding rocket experimenters and cases of separated payloads being passed by a spent vehicle have been documented. A television camera and two motion picture cameras were mounted in the payload module, looking aft. An uplink command system directed an attitude control system to point the payload in any orientation desired by the payload controller. Ground control consoles located in the blockhouse and an autotracker provided a closed loop between the airborne payload and the console operators. A monitor with the real-time television display was also available in the blockhouse.

A television camera with a standard videcon image tube and an F/1.8, 10mm lens was selected for the application. The lens provides



PROFILE DRAWING

A18.805

FIGURE 2.2

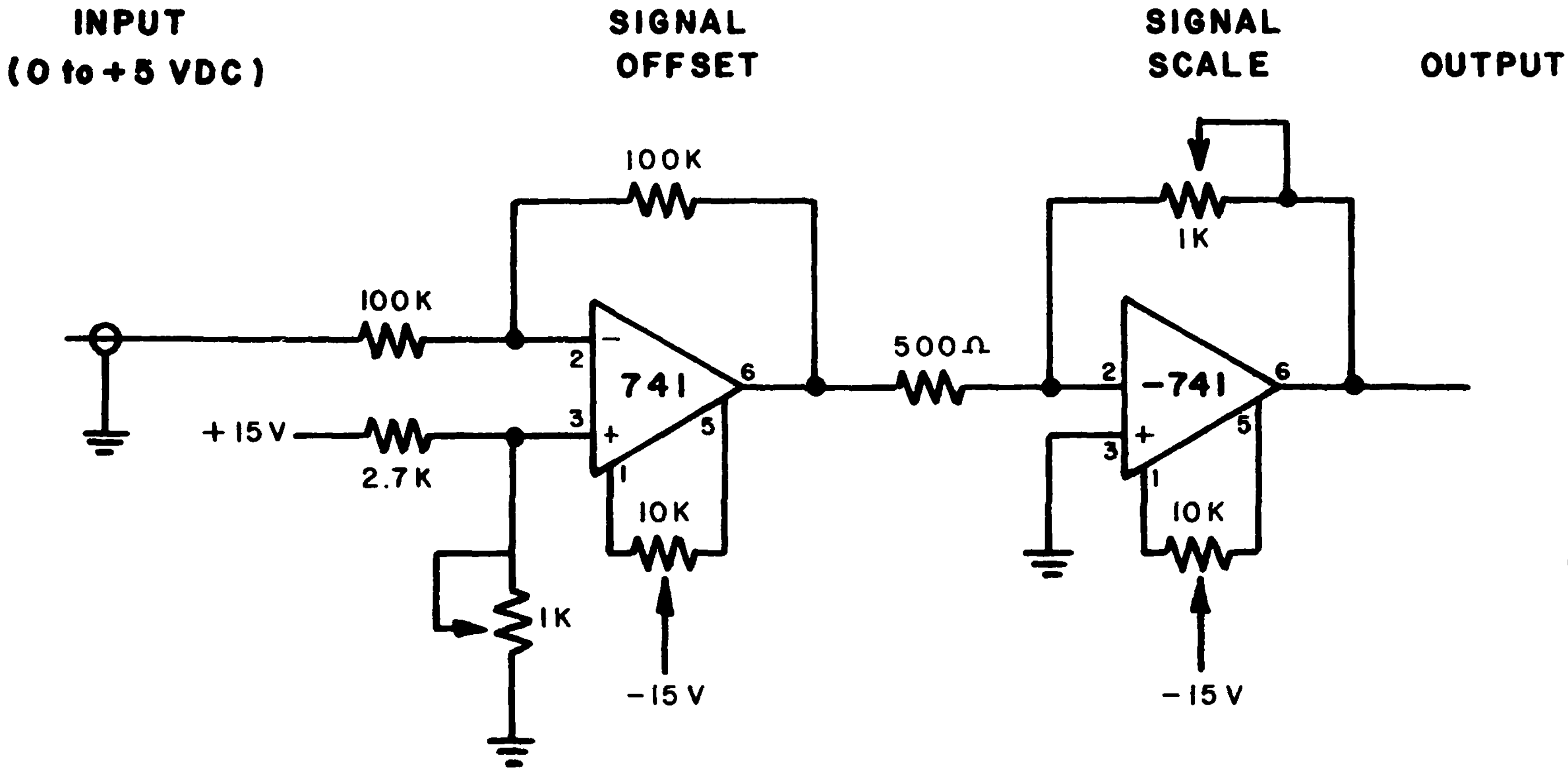
a view angle of 70^{0} x 52.5^{0} and was set to provide a depth of field from 2.7 feet to infinity. Two identical 16mm motion picture cameras, with 35mm lenses were also mounted on the aft deck of the payload instrumentation module. The 60^{0} field of view cameras have a film capacity of 35 feet and a rate of 32 frames per second, allowing up to 45 seconds of operation. Both cameras were looking aft from the payload toward the motor module and booster. The first camera was actuated by the flight sequencer, simultaneous with payload separation, and exposed the full roll of film. A redundant command link function was available for this, and all other sequencer functions, at the payload console. Camera #2 was controlled exclusively from the command link, at the option of payload console operator. A three second overrun of the film is incorporated in the camera mechanism for each burst of the control. Elapsed time meters were included on the payload console. Additional diagnostic instrumentation in the payload module included a low level triaxial accelerometer assembly, temperature sensors and two separation velocity monitors. A simple mechanical system consisting of monofilament line, wound on a large diameter reel was eventually selected to measure the separation. Analog data (0 to +5 volts per revolution) was obtained from a linear potentiometer on the shaft of one of the reels. Higher resolution data was obtained from a shaft encoder on the second separation monitor system. Parallel digital data from the shaft encoder was conditioned to provide both positional information and revolution counts.

Instrumentation in the motor module included a MIDAS gyro platform, a longitudinal accelerometer, augmented by a triaxial accelerometer system and vehicle chamber pressure transducers. An asymmetric array of light emitting diodes were installed forward in the motor module, in the field of view of the television camera. The pattern will confirm operation and orientation of the camera during pre-launch checks.

2.5.1 A18.805 COMMAND CONTROL CONSOLES

In addition to the payload control consoles for each module and the television monitor two command control consoles were required to monitor and command the payload from the blockhouse transmitted uplink command system. System constraints for the command control consoles included interfacing with the telemetry ground station and the master command coder, as well as maintaining compatability with the payload sequencer logic and the attitude control system. Two identical sloping panel instrument cabinets were selected and designated as attitude control system (ACS) command control console and payload command control console. Console functions were divided such that one operator would have only the information necessary to operate the attitude control system. The second operator was stationed at the adjacent console to assist the attitude control operator as well as perform the required payload related functions. Payload attitude was controlled by an eight position joystick and a two position rotary switch on the ACS panel. The film cameras and other payload functions were initiated by momentary switches on the payload console. Relevent monitors are included on each panel. Critical functions, such as T-time, yaw limit and gas pressure are displayed on both consoles.

Outputs from the attitude control system are all 0 to +5 VDC analog signals digitized by the on-board PCM encoder. Signal conditioning circuits in the command control consoles were required to translate the received signals into meaningful real-time data displays for the console operators. Initially the attitude control system is pre-programmed to maintain the predicted attitude at payload separation; i.e. roll returned to uncage position, yaw to be that angle held in yaw memory, and pitch to be the predicted flight path angle. Manual control of the attitude control system from the command control console was at the discretion of the operator, and the system was designed to revert to the pre-programmed mode in the event of a failure in the manual control. The operator also had the option of returning to the pre-programmed attitude at any time during the flight. Modular, plug-in circuit boards were used in each command control console to condition the telemetry signals. Coax connectors on the rear of each console interfaced directly with the output of the DAC, and multiple pin connectors were used to interconnect the two consoles and the master command coder. Telemetry signals were translated to display the gyro positions in degrees and the ACS rates in degrees/second on the digital meters. Figure 2.3 defines the circuitry used for the position and rate signals. The first operational amplifier stage provides the proper offset for the 0 to +5 volt input signal, and the second stage introduces a scale factor. The adjustment potentiometers indicated



SIGNAL CONDITIONING MODULE
COMMAND CONTROL CONSOLE

FIGURE 2.3

are accessible on the rear panel of control console. Payload positions and ACS rates were displayed in degrees and degrees/second respectively on the monitor panel. Position limits are + or -180^{0} for the pitch and roll axes and + or -90^{0} for the yaw axis. Rate displays were set for a maximum of + or -5 degrees/second in pitch and yaw, and + or -90^{0} degrees/second in roll. The gas remaining monitor on the ACS panel was generated from the telemetry gas pressure signal. LED's were illuminated for 100%, 75%, and 50% gas remaining. When the gas reached the critical 25% level all four LED"s were programmed to flash on and off at one second intervals. The 25% level was selected to alert the operator to minimize gas use in anticipation of the final maneuver to the re-entry attitude. Similarly the yaw limit indicator was set to flash if the payload yaw position monitor exceeded + or -60 degrees. Actually, the gyro is capable of + or -85 degrees in yaw, but the conservative 60 degree limit was selected to allow the operator sufficient reaction time. Further details of the command control consoles are described in Reference 22.

2.5.2 A18.805 TESTING

Integration and air-bearing tests of payload A18.805 were conducted at Space Vector Corporation, Northridge, California. Functional checks of the command control consoles were completed, and simulated input signals were used to calibrate the displays and check the adjustment limits of the signal conditioning module potentiometers. Compatability with the master command coder and the 16 channel DAC was confirmed during payload integration checks.

Telemetry signals from the payload were processed through the ground station and verified on the command control consoles. The payload was then installed on the air-bearing fixture. Initially the 13 commands from the command control consoles were actuated sequentially and verified at the payload. A visual target was then set up in the field-of-view of the television camera and the ACS console operator controlled the payload on the air-bearing, aided by the television monitor and the displays on the console. The stationary array in the test area was then expanded to five targets at specified coordinates. Three air-bearing runs of approximately six minutes each were conducted tracing a predetermined path between the five targets. Telemetry data was recorded during each test to confirm the predicted positions, rates, and nozzle fire sequence. Later, a second target panel was added and seven more air-bearing runs were successfully completed, including slewing to predetermined pitch, roll and yaw locations using only the command control console monitors.

Finally, a white target was moved randomly along a dark background and the console operators were able to track the target successfully. Target sizes were sequentially reduced to simulate booster distances of 25, 60, 75, and 100 feet from the aft end of the payload. Telemetry records during the air-bearing runs confirmed that the ACS and the payload functions responded appropriately to the command system.

2.5.3 A18.805 LAUNCH RESULTS

Payload A18.805 was successfully launched on 7 August 1979. Separation of the payload from the boost vehicle occurred, as predicted, at T+66 seconds and was observed on the real-time television monitor in the blockhouse. All sequencer actuated payload functions occurred as programmed, requiring no action from the payload command console operator other than control of the manual film camera.

Post-flight data indicate that the booster separated approximately 19-feet from the payload at an average separation velocity of 1.1 feet/second. Post burnout thrust then caused the booster to accelerate and overtake the payload in approximately 30 seconds; during which time the ACS console operator took manual control of the payload. Since the acceleration of the spent booster far exceeded pre-flight predictions the ACS was not capable of tracking the booster after it passed alongside the payload. Noise on the received telemetry signal in the blockhouse during the early portion of the flight compounded the problem; however, the console operator was able to exercise the control system and orient the payload for a successful recovery sequence. The television signal was solid throughout the flight. All diagnostic instrumentation functioned normally and other telemetry stations recorded data from the payload link. The payload was recovered the same day in excellent condition.

The test proved that solid propellant rocket motors present a possible collision and contamination problem to separated payloads, due to post burnout thrust. Future separation systems will be designed for a delta velocity of no less than 20 feet/second.

2.6 A31.702 PAYLOAD DESCRIPTION

A test flight of the field widened interferometer experiment (FWIF) was planned from the White Sands Missile Range, New Mexico. In this configuration an Astrobee F vehicle was to lift-off the FWIF experiment which also included a Midas Gyro rather than an ACS system and a 17-inch diameter Bristol recovery system.

Integration testing was conducted at Utah State University in Logan, Utah during the week of 8 July 1979

2.6.1 A31.702 LAUNCH DATA

The field support began on 19 July 1979 with personnel arriving at White Sands Missile Range, New Mexico. The payload was first mated to its booster on the launcher on 28 July 1979 and the launch window was opened for a 30 July 1979 launch at 1145 hours. The launch was successfully accomplished on 3 August 1979. All systems performed as expected and data was successfully recorded. Recovery was subsequently accomplished.

2.7 A10.802-1 and A10.802-2 PAYLOAD DESCRIPTION

Payload A08.708-2 (Section 2.4), originally scheduled for launch in the Cluster Ion Program was recertified and identified asA10.802-1. A second identical payload (A10.802-2) was fabricated and both payloads were included in the Solar Eclipse Program.

2.7.1 A10.802-1 and A10.802-2 LAUNCH DATA

The solar eclipse program was conducted at the Red Lake area of Western Ontario and included a total of 14 launches. Payload A10.802-1 was scheduled for launch into the totality of the eclipse, during the period of minimum electron density. The second payload was launched 45 minutes after totality when the electron density was normal. Specifically, these payloads were included in the program to identify the mass number and measure the density of positive and negative ions. Total positive and negative conductivity of the atmosphere, as a function of altitude, was measured by the boom deployed gerdien condensers.

Due to the obvious inflexibility of the launch time and the unique launch facility, the field party was deployed 18 days before the 26 February 1979 total eclipse. Simulated countdowns of the total eclipse program were conducted on 24 and 25 February. A10.802-1 was launched, as scheduled, on 26 February at 10:52:30 local time reaching an apogee of 116 km. After totality, A10.802-2 was launched at 11:41:00 and attained the same apogee. All functions occurred as programmed and data was received from both payloads; however, the telemetry signals were lost at approximately T+500 seconds, indicating recovery system failures. The recovery beacon signal from the A10.802-2 was detected later the same day; however, recovery operations for these payloads did not begin until 27 February. Payload A10.802-1 was located, buried nose first with only the aft three feet of the payload protruding. Attempts to remove the payload resulted in a fracture between the support instrumentation module and the gerdian condenser sections. Efforts to remove the forward mass spectrometer and support instrumentation sections proved futile. The despin housing and the attitude control system are in good condition, and some parts of the recovery and telemetry sections are salvageable. Search aircraft contined to receive signals from the A10.802-2 recovery beacon, but were unable to locate the payload. On 1 March a ground party was deployed to impact area; however, the beacon had stopped transmitting and the payload was not found.

2.8 A13.073 PAYLOAD DESCRIPTION

As part of an international program entitled "The Energy Campaign" to be conducted at launch sites in Andoya, Norway, and Kiruna, Sweden, a payload containing a Circular Variable Filter Spectrometer, CVF, was prepared by Utah State University. A 12-inch diameter payload containing secondary experiments such as an Oxygen Detector, EDS,DC-Probe and two photometers was prepared and supported by other systems such as telemetry, tracking, an analog gyro platform and an in-flight ignition system.

Integration and environmental testing was conducted at AFGL in September 1980.

2.8.1 A13.073 LAUNCH DATA

The field operations began at the Andoya Research Range, Norway with the arrival of personnel on 20 October 1980. The payload was mated to a Taurus Orion booster on the launcher for the opening of the launch window on 5 November 1980. The launch was successfully conducted at 0316 hours Zulu on 16 November 1980. All systems and experiments performed successfully and data was collected for subsequent reduction.

2.9 A10.901-1 and A10.901-2 PAYLOAD DESCRIPTION

The overall profile, the support instrumentation and the orientation of the forward looking quadrapole mass spectrometer are identical to that described in Section 2.4. However, one of the two gerdian condensers in the secondary experiment package was replaced by a retarding potential analyzer (RPA). Minor wiring modifications were required, as well as a new mounting bracket to install the RPA on the existing boom mechanism.

An additional task to this contract was the servicing of the recovery packages for these payloads. This includes acceptance testing each unit, providing flight batteries, and conducting environmental and pre-launch checks. Cabling for the optional turn-around system must also be customized for each payload. The recovery system is discussed in Section 4.2 of this report.

2.9.1 A10.901-1, A10.901-2 LAUNCH DATA

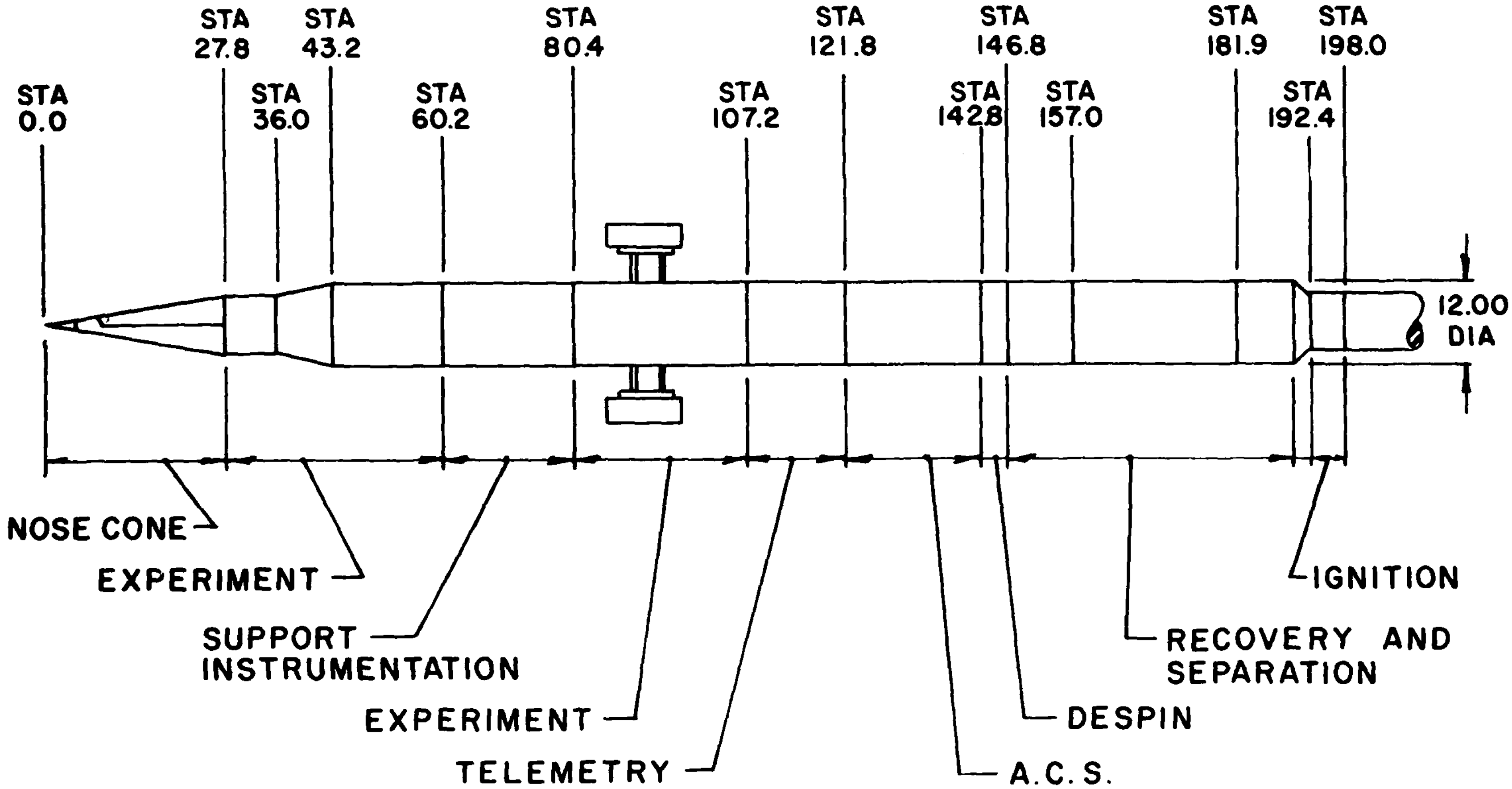
Field operations for the Solar Proton Event (SPE) were unique in that the anticipated event can be predicted in advance by solar activity. Initially a full field crew was deployed to prepare for the opening of the launch window on 12 August 1980. Once the payloads were flight ready the field party was reduced to two technicians, while two teams of support personnel were on standby for the event. Northeastern provided the personnel to maintain the payloads and perform periodic checks of all systems. Both payloads remained on standby status from 21 August through 13 October. A program alert was transmitted on 14 October targeting launches at 0500 hours and 1900 hours the following day. Both payloads were mated to the vehicles while the remainder of the support crew traveled to PFRR, but the intensity of the proton event was not sufficient for launch. Several payload problems were encountered and resolved during subsequent system checks.

No solar proton event was emminent and the contingency plan to launch a payload to collect background data and to provide an engineering test of the overall system was initiated. On 22 October, A10.901-1 was launched during a magnetic disturbance. Data indicate that all up-leg functions performed normally and the mass-spectrometer and the secondary experiment signals were as predicted. The recovery and turn-around systems performed flawlessly and the payload was recovered in excellent condition the day after launch. A second SPE program is scheduled for 1981 using the same payload systems.

2.10 A30.072 PAYLOAD DESCRIPTION

This contract was assigned the task of refurbishing a 17-inch diameter payload section housing the telemetry and support instrumentation systems for the field widened interferometer (FWIF). In the original configuration (A31.702) an attitude sensing gyro was included in the telemetry section and no in-flight timing was required. Modifications included the deletion of the gyro, the addition of an attitude control system, and the addition of program timers to initiate the attitude control functions.

Squib batteries were also added to payload A30.072 to actuate recovery, despin, and separation functions from the payload timer.



PROFILE DRAWING
A10.901-1

FIGURE 2.4

Integration tests were accomplished in two steps. Vibration, shock, and post-environmental tests of the telemetry/support instrumentation section were conducted at AFGL, after which the module was shipped to Utah State University for integration with the experiment and nosecone section.

2.10.1 A30.072 LAUNCH DATA

Field operations for payload A30.072 began on 24 April and the payload was first mated to the vehicle on 2 May. A vacuum leak was detected during vertical checks, necessitating a three day slide in the launch schedule. The payload was returned to the pad on 7 May and countdowns were conducted the next four days, despite continued problems with the instrument. Hold time for the interferometer was reduced to approximately 30 minutes, severly hampering countdown flexibility for the auroral event. The mission was eventually cancelled on 15 May and rescheduled for a launch window beginning on 23 January 1981.

The payload was returned to PFRR, Alaska, on 12 January 1981 and set up on the launch pad on 27 January 1981. The launch of A30.072 occurred successfully on 5 February 1981 at 0126 hours. All functions performed as predicted except the experiment slide release didn't occur. Recovery was accomplished within 12 hours with the payload in excellent condition.

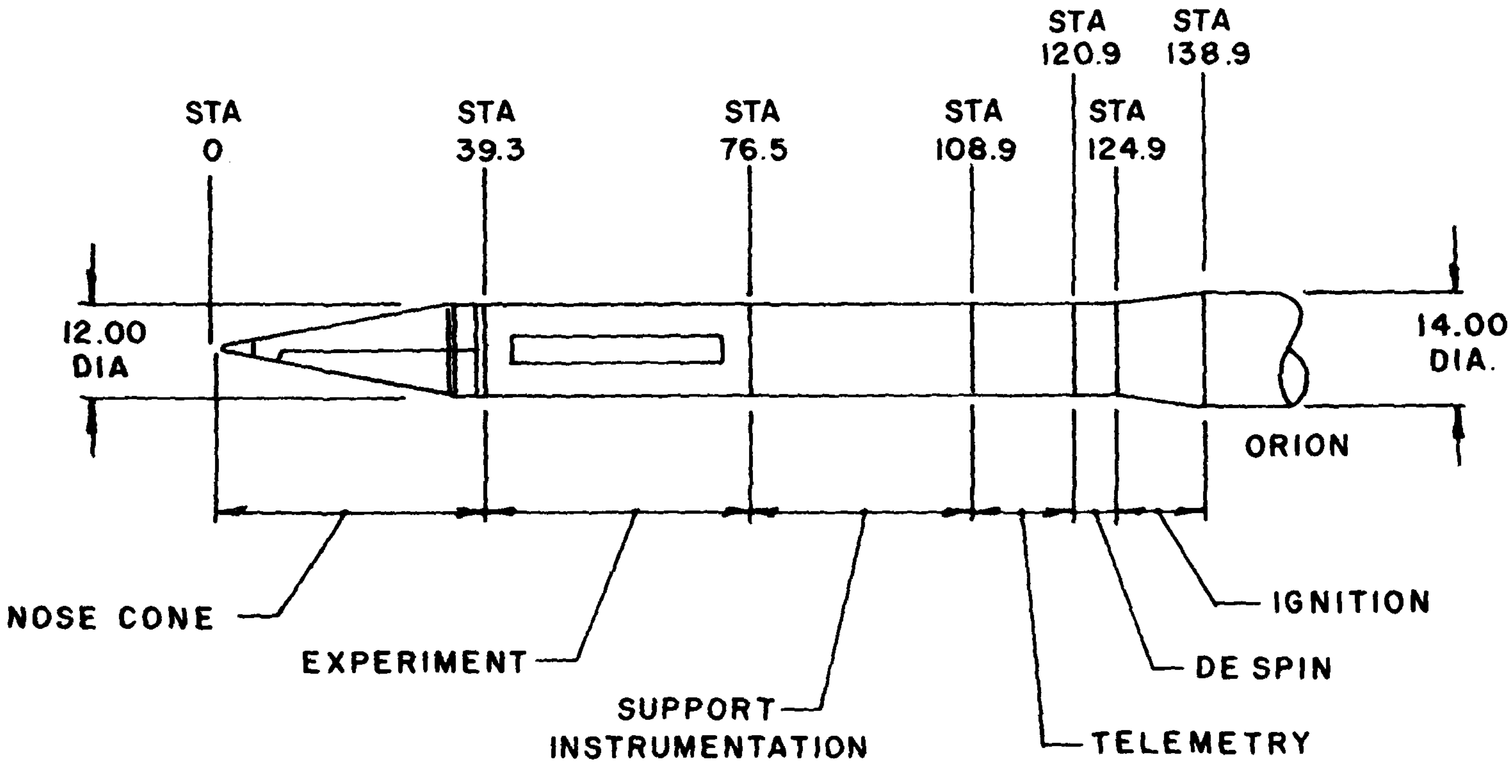
2.11 A13.020 PAYLOAD DESCRIPTION

A forward looking, switched positive ion/neutral mass spectrometer, an energy deposition scientillator (EDS) and a pair of pulsed-plasma-probes were packaged in the A13.020 payload. The

65.5 cm. long probes required a gold plated payload exterior for conductivity. In order to minimize length, the 9-inch diameter nosecone and transition section were replaced with a full diameter nosecone and a 12-inch cylinder to house the instruments. Further, the cylinder length constraint defined by several plating companies (35 1/2 inches maximum) required relocating the EPS and its related door mechanism in the support instrumentation section. A MIDAS analog gyro platform was added to the usual complement of instrumentation, since an attitude control system was not included. As indicated in Figure 2.5, individual telemetry, despin and in-flight ignition housings were located aft of the instrument section. Recovery was not included due to weight constraints, precluding the need for payload separation.

2.11.1 A13.020 LAUNCH DATA

A13.020 was one of four payloads in the Auroral-E Programs at PFRR. The program was designed to provide data to test theoretical models used to develop remote sensinq systems for auroral optical measurements. A diffuse auroral condition, caused by a relatively stable stream of incoming electrons and protons was required. Specifically, payload A13.020 was designed to determine the neutral and auroral plasma composition (mass spectrometer); to provide total electron deposition (EDS): and to measure electron and ion density (Pulsed-plasma-probes). This payload was the second launched in the program. Two of the remaining Auroral-E payloads are described in the following section.



PROFILE DRAWING
A13.020

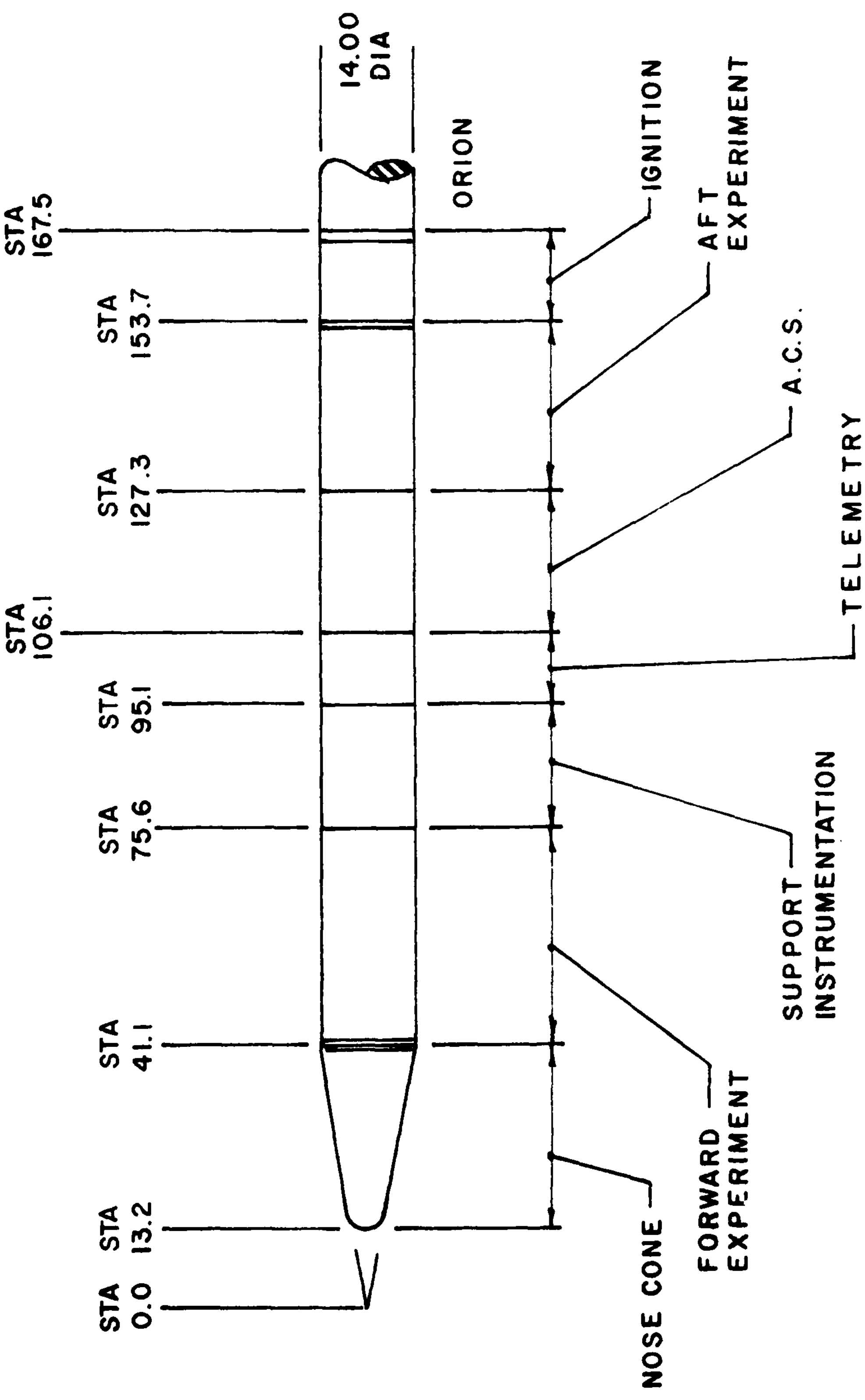
FIGURE 2.5

Operations began at PFRR, on 12 February 1981, culminating in a simulated countdown for the program on 25 February. Several countdowns to the built-in hold time were conducted during the next eight days; but, auroral conditions, range radar problems, and weather conditions precluded the launches. Launch of the program finally occurred on 6 March. Vehicle and payload systems on A13.020 performed flawlessly and data was received from all three experiments.

2.12 A13.030 and A13.031 PAYLOAD DESCRIPTION

Both forward and aft looking instruments were included in payload A13.030 and A13.031. Electron proton spectrometers (EPS) were common to all four instrument sections; however, in A13.031 both of the aperture plates were required to be positioned at a 30 degree angle to the roll axis. Other instruments in A13.030 were a five-channel, ultraviolet grating photometer and six (6) individual filter photometers in the forward instrument section and six (6) similar filter photometers looking aft. In addition to the EPS, a single channel ultraviolet photometer and two (2) 0.125 meter spectrometers were packaged in the A13.031 forward instrument section. A light source was also required to provide reflected light for evaluating spectrometer data during pre-launch checks and during boost, prior to nose cone ejection. Individual PCM encoders were packaged in each instrument section to accommodate the varying data requirements of each instrument group.

As indicated on the A13.030 profile drawing (Figure 2.6) support instrumentation, telemetry and attitude control sections



PROFILE DRAWING

A13.030

FIGURE 2.6

were packaged between the forward and aft experiment modules. The configuration of A13.031 was identical, except that the forward experiment section was 21.61-inches long and the aft experiment required only 18.0-inches. A unique problem was encountered in the design of these payloads to satisfy the sealing requirements of the experiment sections. Previous separation mechanisms, not requiring sealing, utilized actuators that were perpendicular to the release mechanism. This concept precludes sealing the cylinder in the separation area. A manacle ring system, using actuators installed outside the sealed area at a 45 degree angle was developed. Details of the high retention manacle ring design are reported in Section 4.4.

The in-flight ignition components for these payloads were reconfigured to the 14-inch diameter cylinder which also housed the payload/booster delta velocity system. Initially a spring array, similar to the one used for forward nosecone eject was incorporated to provide the delta velocity. Concern with the limited separation velocity attainable with springs led to the selection of a squib valve actuated pneumatic system. Additional advantages of the pneumatic system are the absence of pre-load forces during assembly and the ability to change the separation velocity by merely varying the tank pressure, even after assembly.

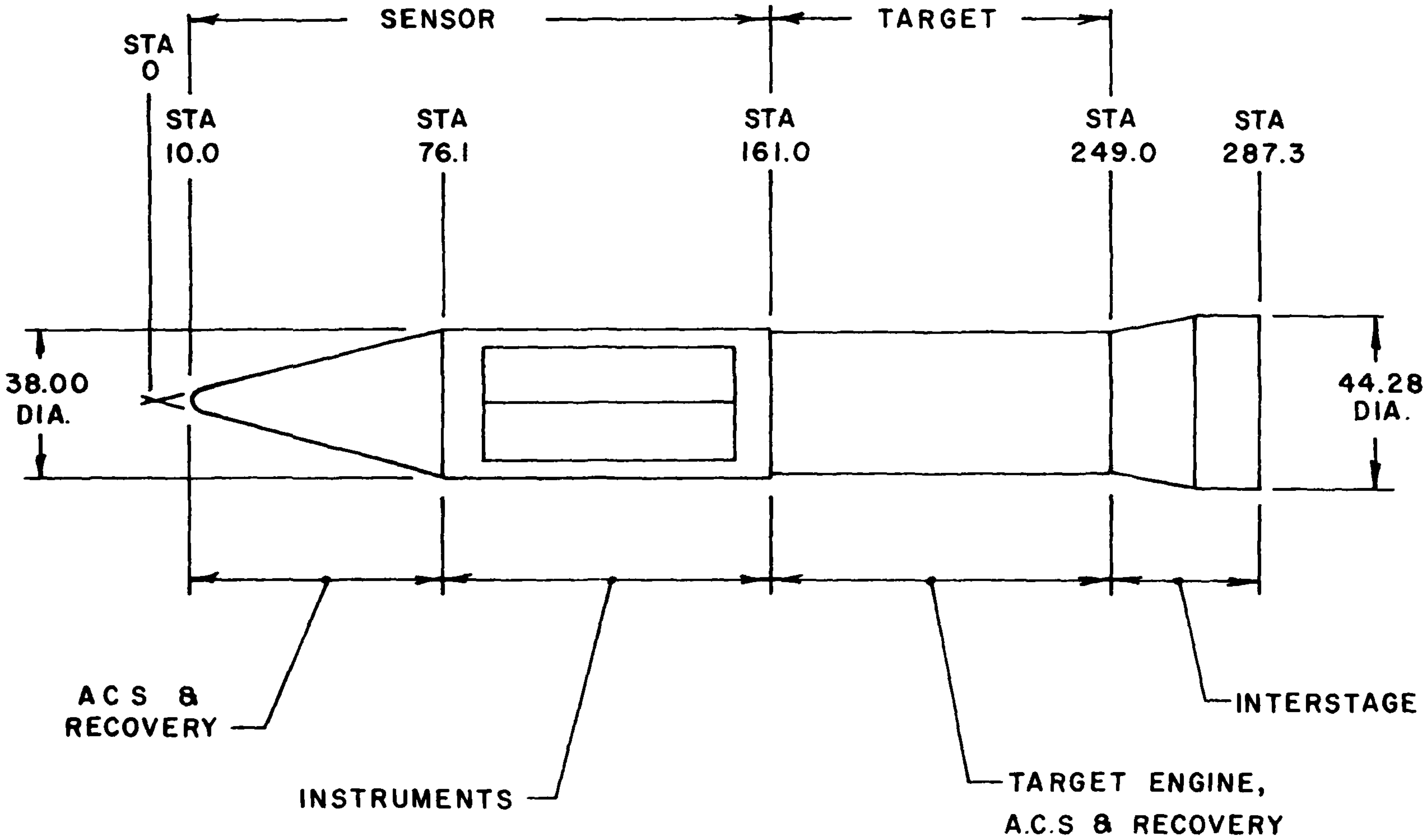
2.13 A13.030 and A13.031 LAUNCH DATA

Payloads A13.030 and A13.031 were part of the Auroral-E Program described in Section 2.12. The purpose of the four (4) EPS instruments was to measure the electron and proton energy of the diffuse aurora. Optical spectra were measured by the remaining instruments on these payloads. Due to manufacturing problems only six (6) of the anticipated twelve (12) filter photometers were available for integration checks. All photometers were installed at the launch site.

Testing and launch preparation of these two payloads closely paralleled the schedule described in the previous section for payload A13.030. Vacuum checks of the four (4) sealed experiment sections, functional checks of the manacle ring separation systems, and leak rate checks of the delta-velocity components were unique to payloads A13.030 and A13.031. The Auroral-E Program was initiated at 2210 hours AST, on 6 March when A13.030 was launched, followed by A13.020 one minute later. Twenty minutes after the initial launch, A13.031 lifted-off. Desired auroral conditions persisted throughout the launch sequence. All vehicle and support functions occurred as scheduled. High voltage power supply problems developed in one forward and one aft EPS during the flights. Data were received from all other instruments, but has not yet been fully evaluated. Recovery systems were not provided on these payloads.

3.0 MULTI SPECTRAL MEASUREMENTS PROGRAM (MSMP)

The concept of the MSMP is different from the sounding rocket payloads described in the previous section. Rather than measuring natural phenomena in the upper atmosphere, the instruments in the sensor portion of the payload measure the burn characteristics of a target engine. As indicated in Figure 3.1 the sensor module and the target engine are launched from a common, single stage Aries I



PROFILE DRAWING MSMP PAYLOAD

FIGURE 3.1

booster. Recovery systems and attitude cont·ol systems are included in both modules.

At approximately 90 km altitude the sensor module and the target engine module will be separated and individually controlled on different trajectories. Both attitude control systems will be preprogrammed and updated with an on-board tracking system. A radio frequency interferometer tracking system provides error signals to the pre-programmed attitude control system, and allows closed-loop operation between the modules to maintain the precision viewing required by the sensors. After separation, the sensor module will be oriented such that the optical instruments will be pointed at the plume of the target engine as it proceeds through a number of burns during the course of its trajectory. Mission plans will be established to vary target engine burns and trajectories for each launch.

3.1 MSMP SENSOR MODULE

Northeastern University was responsible for the mechanical and electrical integration of the MSMP sensor section. Design parameters of the structure, the flight sequencer, the diagnostic instrumentation, the television system and the 35mm camera are detailed in Reference 5. An additional requirement that crosshairs be superimposed on the picture produced by the television camera was also investigated. Initially a disk with fine lines etched on it was inserted between the lens and the silicon vidicon tube. This approach was found to be unsatisfactory since the F/.7 lens caused the finest line that could be etched on the disk to appear about an inch wide on the monitor. Crosshairs built into the silicon vidicon were then considered and discounted as impractical. Finally a circuit to electronically introduce a simple crosshair pattern was developed. The circuit detects the horizontal and vertical sweep synchronization pulses and then uses a series of counters and oneshot multivibrators to generate horizontal and vertical lines which are consequently synchronized to the picture. The brightness of the lines may be adjusted so that picture features are seen through the lines. Since picture detail is not completely masked, a simple crosshair proved to be acceptable and an open center type crosshair was not required. A comparator is used to separate the sync pulses from the video. The sync pulses are then used to trigger the oneshot and drive the counters. The oneshots produce positive pulses which are added back into the video to brighten the picture at certain spots producing vertical and horizontal lines. The electronic crosshair circuits were packaged in the de-emphasis filter units used in conjunction with each receiver and monitor.

Motor drive systems used to operate the sensor module doors and latches were a significant part of the payload operation. Details of the geneva drive mechanisms and the current limit concept used to control the motors are included in Scientific Report Number 2 (Reference 16) of this contract: "Motor Drive Systems for Sounding Rocket Payloads".

3.2 A24.609-1 (TEM-1) PAYLOAD DESCRIPTION

The first MSMP payload was identified as A24.609-1 or TEM-1 (Target Engine Measurements). A total of ten (10) scientific instruments were included in the TEM-1 sensor module. Mechanical design allowed for variations in the instrument complement by sectioning the upper portion of the dust shield and providing three interchangeable auxiliary dust shields. The TEM-1 sensor module consisted of the following instruments:

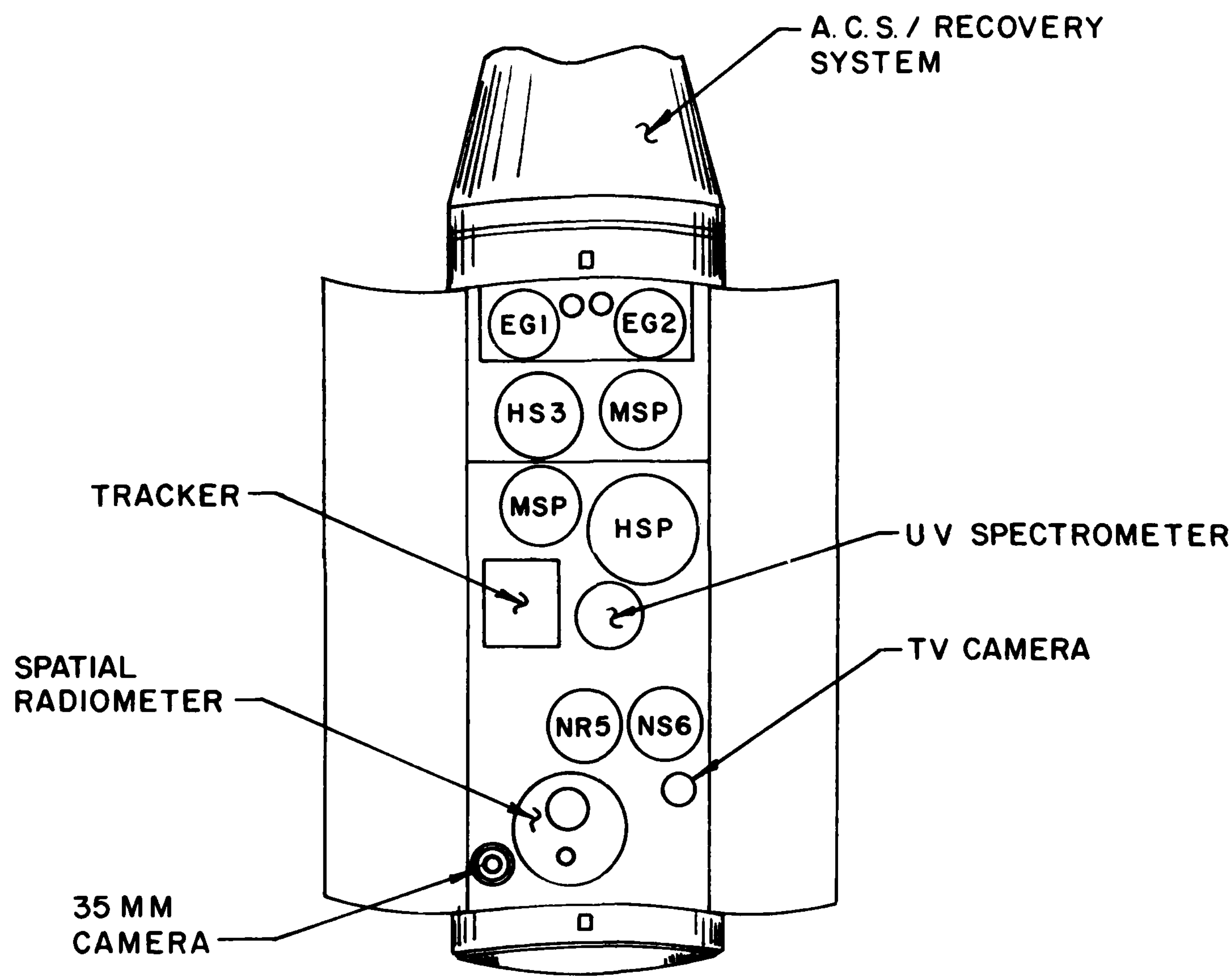
Infrared Sensors

1. Full Field Radiometer (NR5)
2. Spatial Radiometer
3. Circular Variable Filter Spectrometer NS6)
4. LWIR Circular Variable Filter Spectrometer (HS3)

Ultraviolet Sensors

1. High Sensitivity Photometer (HSP)
2. Medium Sensitivity Photometer I (MSP1)
3. Medium Sensitivity Photometer II (MSP2)
4. Ultraviolet Spectrometer
5. Electrographic Camera I (EG1)
6. Electrographic Camera II (EG2)

Figure 3.2 illustrates the location of the sensors as well as the tracker, the television camera, and the 35mm camera.



TEM I
SENSOR MODULE CONFIGURATION

FIGURE 3.2

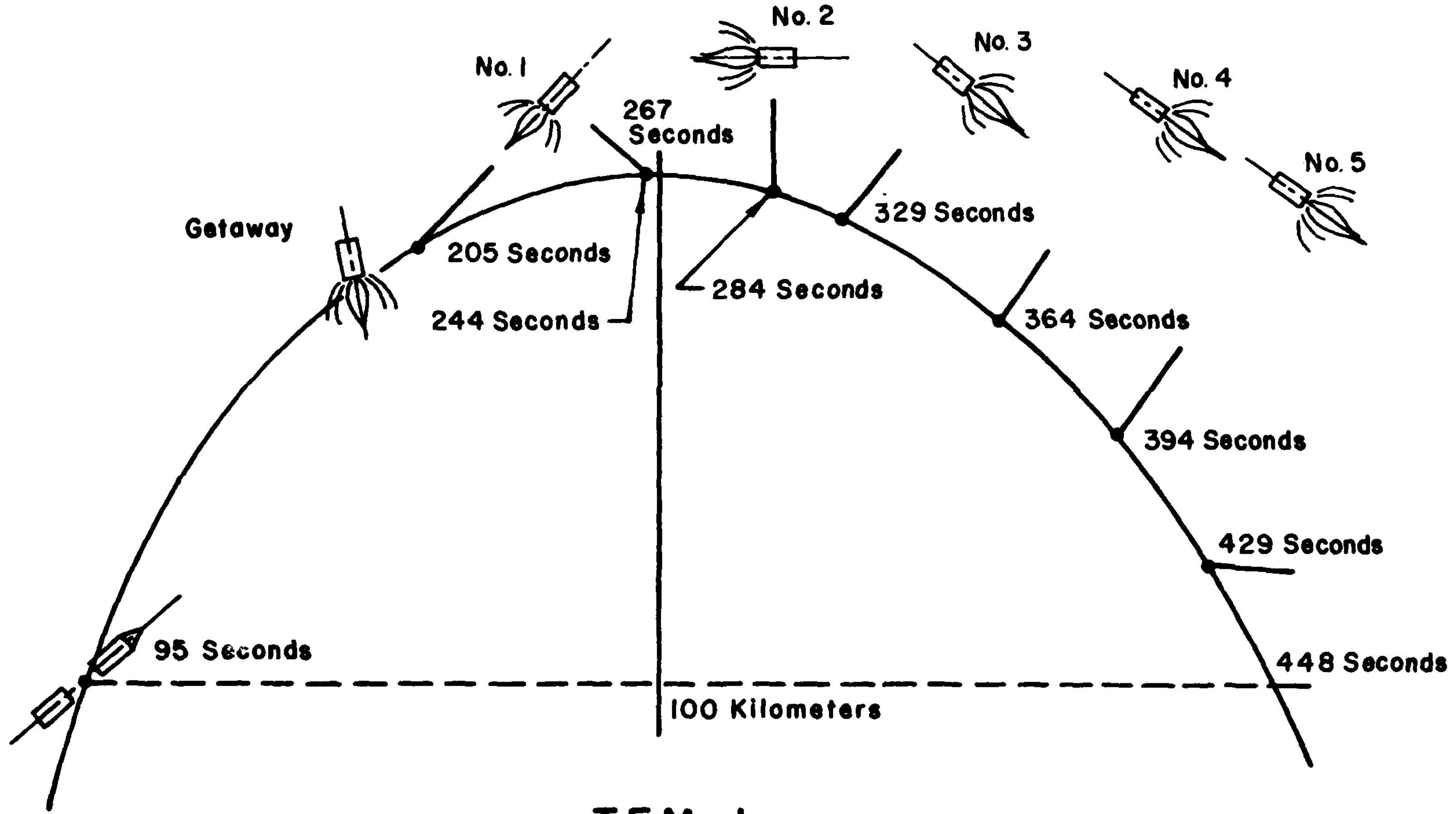
3.3 A24.609-1 (TEM-1) LAUNCH DATA

Tracker operational and alignment tests were conducted at the Physical Science Laboratory (PSL), University of New Mexico facility in mid October 1977. The sensor module was then transported to White Sands Missile Range for pre-launch checks.

Final assembly of the sensor section and instrument boresight alignment was completed in the Vehicle Assembly Building on 7 November. The following day the sensor section was mated to the sensor attitude control/recovery system and subsequently to the target module on the Aries pad.

Figure 3.3 illustrates the TEM-1 mission profile. After booster burnout the sensor and target are separated from the booster, reoriented and then separated from each other. After 110 seconds of coasting, the first firing of the 313 pound thrust target engine increases the target velocity, resulting in the target flying above the sensor at an ever increasing distance. This firing is designated "getaway" burn and is not observed by the sensors. The second burn occurs near apogee at a sensor to target range of one kilometer. The final burn ends at an altitude of 500,000 feet and a range of 12 kilometers. Sensor module timing functions were correlated to the programmed target burn sequence.

All sensor systems performed as predicted during the ten (10) hour countdown on 10 November, and liftoff occurred on schedule at 2100 hours MST. Apogee of the sensor was predicted to be 240,022 meters at 267.4 seconds; however, radar data indicated a peak of 227,906 meters at 261.5 seconds. Analysis of the TEM-1



TEM-I
MISSION PROFILE

FIGURE 3.3

flight data revealed failures in the sensor attitude control system, the sensor recovery system, and the sensor/target tracking system. Logic relay and function monitors indicated that all sensor module events occurred at the programmed times. Telemetry records also indicate that battery supplies, motor control circuits, cap eject mechanisms, diagnostic instrumentation, and the television camera performed as predicted.

Failure of the sensor doors and the transducer power supply were the result of the attitude control system malfunction and a lower-than-predicted trajectory. Telemetry monitors indicate that the door closing sequence began on schedule and the doors were partially closed when high aerodynamic loads ripped the doors away from the structure. The transducer power supply failure coincided with the door problem, and the telemetry monitor indicated a direct short circuit. Obviously the potentiometers used to monitor the instrument door position were also damaged. Apparently the potentiometer power from the transducer power supply was shorted to the structure and some diagnostic instrumentation data was lost at that time. A second regulated power supply was added to TEM-2 and subsequent MSMP sensor modules. The original transducer supply is used only for the accelerometers, thermistors, and logic relay monitors. Door position monitors, latch mechanism monitors and instrument cap eject monitors are powered from the added regulator. Recovery operations the following day revealed the sensor module was near the predicted impact area; however, no sensor components were salvageable.

3.4 A24.609-2 (TEM-2) PAYLOAD DESCRIPTION

Initially the TEM-2 structure was used for instrument and antenna fit checks, concurrent with the wiring of the TEM-1 sensor module. On 21 April 1977 the assembly was shipped to PSL and installed in the antenna range tower. Successful antenna pattern and tracker boresight test were conducted and procedures were established for future functional tests with the fully instrumented sensor modules. Two experiments were deleted from the TEM-1 configuration. Unresolved detector problems with the ultraviolet spectrometer eliminated that instrument from TEM-2. One of the medium-sensitivity photometers (MSP-2), destroyed in TEM-1, was scheduled to be refurbished for the second launch. Another significant modification to the TEM-1 configuration was the addition of ejectable caps to the NRL ultraviolet cameras. Elimination of the forward window improves the resolution of the cameras by a factor of two. Additional connectors in the dust shield, larger interface connectors on the camera control deck, re-routing of sequencer control lines, additional control relays, and wiring modifications to the squib logic box were required to accommodate the ejectable caps.

Component and system test procedures were critically reviewed after the TEM-1 experience. A vacuum test of the entire sensor module was added and instrument door tests were conducted to determine operating levels under various loads and current limit settings. The sensor module was suspended with the instrument doors facing down and the angle of the module from vertical was varied. The component of gravitational force (sine of the angle from vertical) acts on the sensor doors during the closing cycle. Operation was well within design specification for a normal launch trajectory. Test results are reported in Reference 14.

3.5 A24.609-2 (TEM-2) LAUNCH DATA

The TEM-2 sensor module and ground support equipment were shipped to WSMR on 10 August 1978. The sensor module was installed in the PSL antenna tower on 22 August. Boresight and mapping of the RF tracker were accomplished, using the procedures developed during the similar TEM-1 operation. Final assembly and recheck of all sensor module systems was completed on 5 September before beginning the clean room operation at LC-37. The following day the sensor module was transported to the pad, mated to the target engine module, and umbilicals were rigged and checked. The 9-hour countdown began at 2146 hours MDT for the scheduled 0646 hours MDT launch on 7 September. Pre-launch operations were on schedule and the T-180 minute range check was successfully completed; however, the launch was aborted due to the inadvertent separation of the payload from the booster, and subsequent separation of the sensor module from the target engine module during the T-105 minute check. Final arming of payload systems was completed prior to the timer cycle and the target engine module timer was not interruped during the test count. The separations occured at T+85 seconds and T+90 seconds, respectively; and the mission was aborted. The sensor module was removed from the pad and inspected for damage. Only surface scratches on the skin panels and the aft deck were obvious.

Several modifications to the target engine module resulted from the TEM-2 field experience. Primary impact on this contract was to provide control capability of the RF systems in the target engine module at the sensor module telemetry control console. This necessitated re-allocation of sensor module umbilical lines; addition of control lines from the target/sensor interface connector; and wiring modifications to the blockhouse distribution box. Payload arming procedures as well as the countdown sequence were critically reviewed by personnel from all concerned agencies. Several changes were implemented, including the deletion of the T-105 minute check and the delineation of pad personnel and console operator functions during the countdown. On 30 April 1979 a field party travelled to WSMR to determine the status of the sensors and support systems. A complete check, excluding the electrographic cameras was completed on 3 May. The sensor module was then prepared for storage at WSMR until July.

Pre-launch operations at PSL and WSMR were repeated during September 1979. At 1929 hours MST on 25 September the 11 1/2 hours countdown began, following the revised countdown procedures. All pre-launch operations and checks occured on schedule until T-14 seconds when a hold was called. One of the four nozzle monitors on the Aries motor failed to indicate a position change during the pre-launch sequence, necessitating the hold. Since the squib-actuated nozzle control battery had been committed at T-27 seconds the booster was no longer functional. The sensor module was then returned to the LC-37 clean room. Investigations revealed that a bent pin in the vehicle interface connector caused the erroneous monitor. During the following four days a replacement booster was prepared and installed on the launch pad. On 1 October, the target and sensor modules were mated to the vehicle and system checks were repeated for the anticipated 3 October launch; however, the launch was cancelled to allow re-certification of the booster. The sensor module was again transported to the LC-37 complex where instruments were removed and the payload and equipment were packed for shipment.

Sensor module systems were re-certified at AFGL and TEM-2 was returned to WSMR in May 1980. The 11 1/2 hour coutdown progressed smoothly and the launch occured, as scheduled, at 0608 hours MDT. Post flight data indicated that all sensor module support systems performed as predicted during the critical data portion of the TEM-2 flight. Anomalies in the power transfer control system and the vent door operation were noted during re-entry. Neither was detrimental to sensor module performance. Data was received from all instruments and the overall flight was deemed a total success. Recovery operations began immediately after impact and the sensor module was returned to the launch complex in excellent condition.

3.6 A24.609-3 (TEM-3) PAYLOAD DESCRIPTION

Early in the MSMP program the TEM-3 sensor module was used for optical alignment tests, for air flow cycles to determine filter requirements, and to confirm the integrity of the structure. Two axis load tests were conducted using the AFGL bend test facility. In early 1980 the sensor module was wired as a possible backup to TEM-2.

The instrument complement for the TEM-3 sensor module was defined December 1980. Differences from the TEM-2 instruments include the deletion of the electrographic cameras, the addition of a second medium sensitivity UV photometer, and the substitution of the redesigned NR, NS, and HS cryogenic instruments. All three instruments are smaller in diameter than their predecessors, necessitating modifications to skin panels, mounting plates, and dust shields. In addition, the squib actuated cap mechanisms have been replaced by motor drive systems requiring changes in the power allocation, signal interface and umbilical distribution.

Pacing item for the proposed November 1981 launch is the coundition of the focal plane on the recovered spatial radiometer. Mechanical and electrical design modifications will be initiated during the follow-on contract after the 27 April design freeze date.

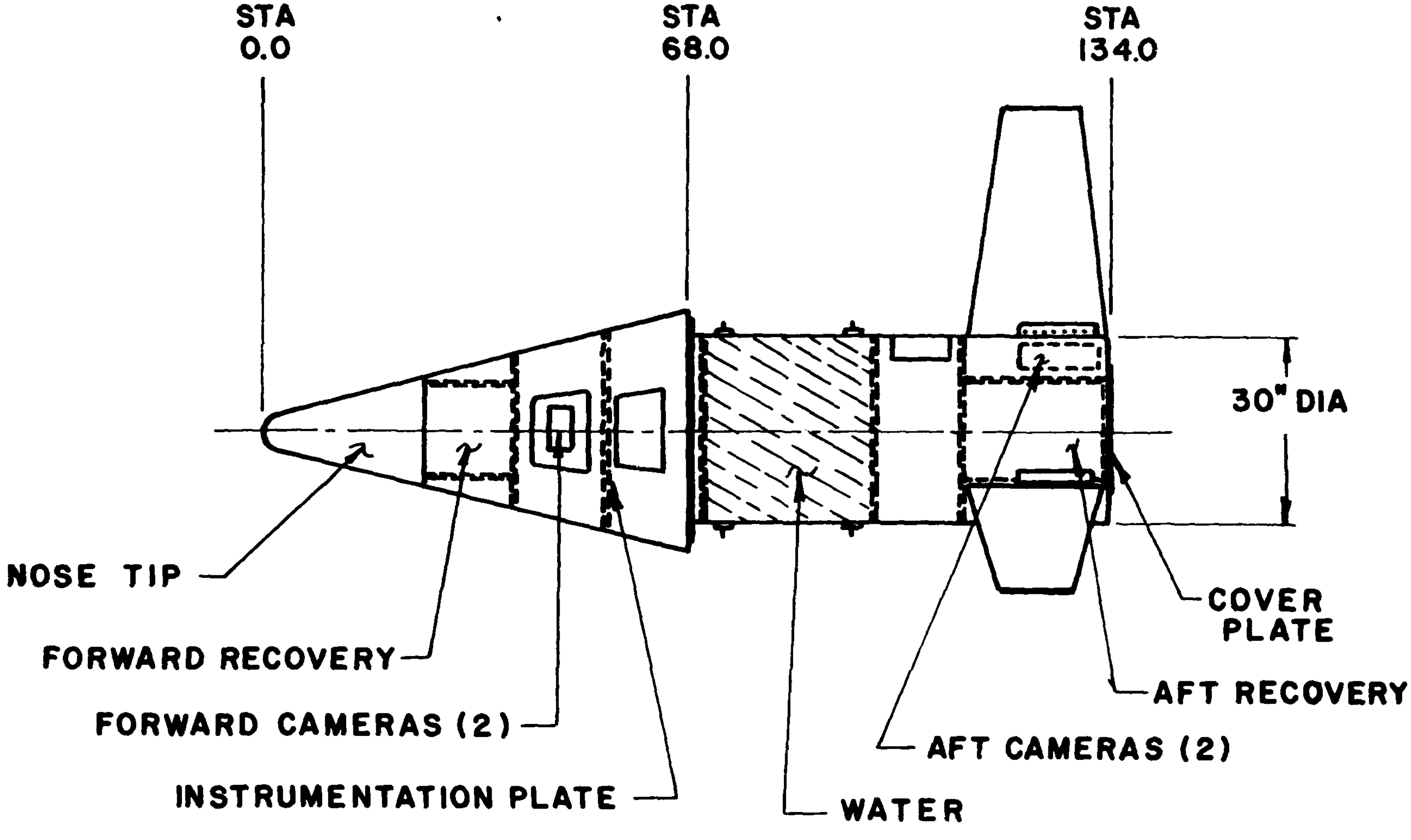
4.0 PAYLOAD SYSTEMS

Several of the general projects related to the previously described payloads are discussed in the following sections. Other efforts included: investigation of new components and instrumentation; testing and evaluation of potential flight batteries; design and fabrication of battery servicing consoles, EPROM programmers, and countdown clock panels; and testing of separation, ejection and deployment mechanisms. The Quarterly Status Reports for the contract period contain details of the above systems and investigations.

4.1 73 - FOOT PARAFORM RECOVERY DROP TESTS

An aircraft drop test program was conducted to qualify a 73-foot paraform recovery parachute system. A total of six air-drop tests were conducted at the Air Force Flight Test Center (AFFTC), Edwards Air Force Base, California. Northeasterns' responsibilities on this project included the design and fabrication of an instrumentation package to monitor the performance of the recovery system. Diagnostic instrumentation consisted of five angular rate sensors, three low level accelerometers, a longitudinal accelerometer, and two magnetometers. Two film cameras were also packaged on the instrumentation plate, and external mirror mounting brackets were designed to enable the side viewing cameras to observe nosecone separation and forward parachute deployment. The "*Heavy Gross Weight Drop Test Body*" used in the first four tests is depicted in Figure 4.1. As indicated, the instrumentation plate and forward cameras are located in the nosecone which is similar to that flown on MSMP and other Aries payloads.

Instrumentation and control consoles were shipped to Space Vector Corp., Northridge, California where the drop body was assembled and checked, then transported to Edwards AFB. An aft recovery configuration was used for the first drop of the 2,000 pound payload, which occurred on 30 June 1979. Two aft looking cameras, provided by AFFTC, recorded drogue and paraform deployment. Although no parachute was included in the forward canister for this test, the nose tip eject system was tested and observed by the forward cameras. All systems functioned normally and the



HEAVY GROSS WEIGHT DROP TEST BODY

FIGURE 4.1

drop body and paraform were recovered in excellent condition.

The drop body was reconfigured for a forward parachute deployment and a second successful drop was conducted on 17 July 1979. This configuration simulates that employed on MSMP, which formerly utilized a 66-foot diameter paraform. Stability of the drop test body was greatly improved for tests three and four by increasing the total fin area from 7.5 square feet to 15 square feet. The increased fin area provided the desired, adverse nosedown attitude at drogue parachute deployment. These tests were conducted on 31 July and 6 August. Tests five and six utilized the aft recovery canister and were not instrumented. The entire nosecone and the fins were eliminated to attain the desired low gross weight.

In summary the six tests demonstrated that the 73-foot diameter paraform recovery parachute system is capable of recovering payloads ranging in gross weight from 1,100 to 2,043 pounds. Further, the parachute system deployed satisfactorily at a maximum dynamic pressure of 246.5 pounds per square foot from a vehicle in an adverse, nosedown attitude.

4.2 PAYLOAD RECOVERY SYSTEM

Space Data Corporation, Tempe, Arizona, developed a 12-inch diameter recovery system which includes an optional payload turnaround system. Northeastern personnel reviewed the Space Data design and recommended an electrical interface that was adaptable to a "typical" payload. It was resolved that three interface connectors would be installed at the forward recovery package joint, and that Northeastern would supply and service two nicad battery packs to power redundant Space Data systems. One interface connector provides battery charge and monitor capability through the forward payload umbilical. Power to the vehicle separation squibs and the vehicle tumble motor squibs will be actuated by the payload sequencer and fed through a second connector. The remaining connector will be utilized only when a recovery beacon is flown.

The contractor was also assigned the task of designing and fabricating a drop body for aircraft drop tests of the recovery system. A three-fin configuration, 6-feet long, and weighing 413 pounds is required. Three recovered skin sections and a standard ballast housing were coupled and lead disks were fabricated to provide variable ballast. Fin mounting brackets, fins and hardware for the turn-around housing were also furnished. The system was shipped to Edwards AFB and the first drop occurred on 4 January 1980. All systems, including the turn-around mechanism, performed as predicted and the drop body was recovered in good condition. A second successful drop test was conducted in February and the recovery/turn around system functioned properly in conjunction with the launch of payload A10.901-1 (Section 2.9) at PFRR.

4.3 PAYLOAD TIMER - MODEL 2480

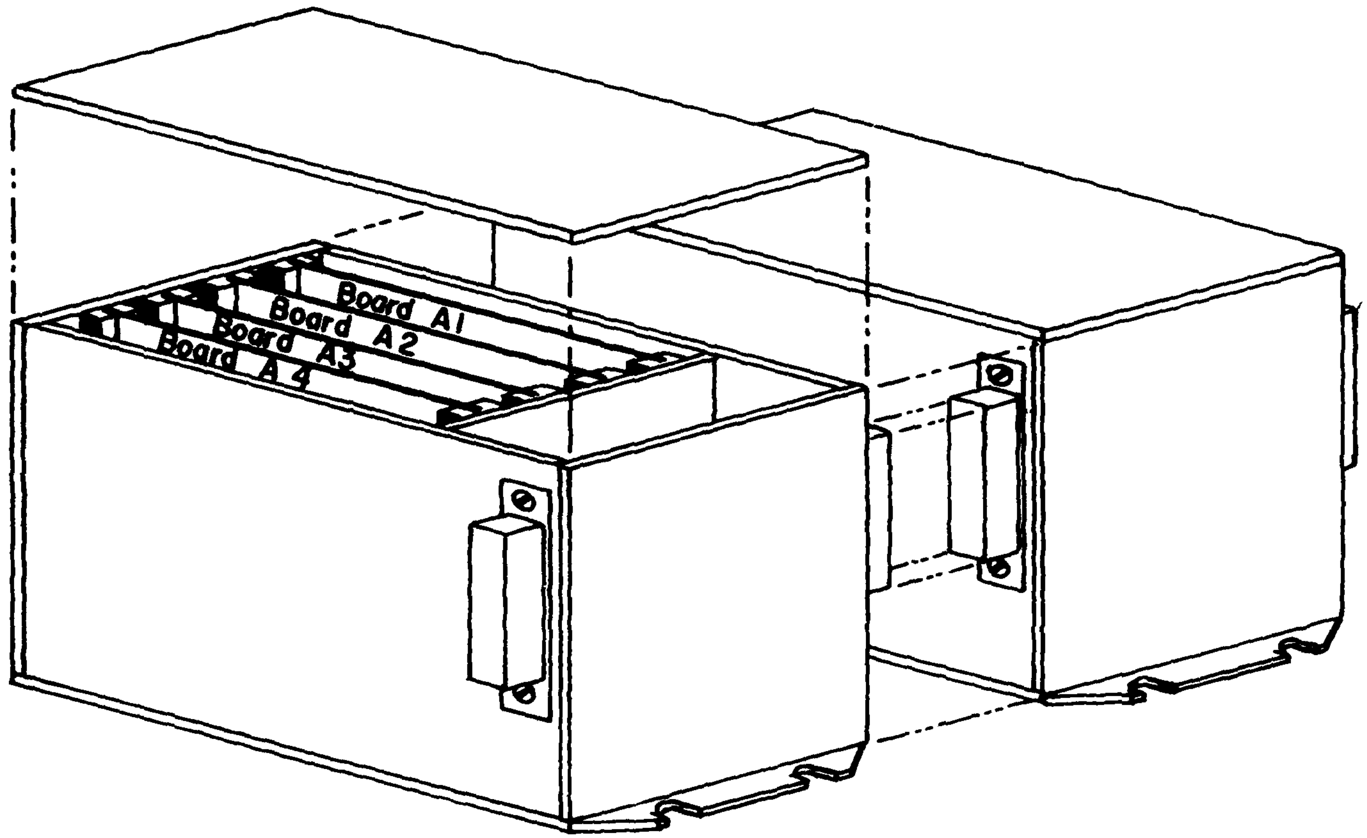
Increasingly complex in-flight timing requirements and the non-availability of the RM-256A electrically alterable memories used in the Model 50 timer (Contract No. F19628-C-73-0152, Scientific Report No. 3) necessitated a new timer design. A 16,384-bit

EPROM was selected as the memory element. Clock, counter, and output circuits are similar to the Model 50 timer and the MSMP sequencer. Several packaging concepts were considered.

Previous digital timer/logic systems consisted of a timing module packaged on wire-wrap panels, and individual relay logic boxes to interface with the experiments and support systems. Investigations led to an integral timer/logic unit with five (5) printed circuit boards. The overall timer package is 6.5 inches x 3.5 inches x 3.25 inches with provisions for two 50 pin input/output connectors. If a single timer is used, only one connector is necessary. The optional connector provides redundant clock and output signals. Direct mating of the prime and backup timer redundancy connectors is accomplished when the timers are located side-by-side. If this packaging configuration is not feasible, redundancy can be attained with an interconnecting cable. The outboard connectors on each timer interface with the payload wiring harness. A redundant timer is shown in Figure 4.2. The mother board (A5) provides interconnection between the four component boards and interfaces with the input/output connectors. The component boards are defined as follows:

A1 - Clock Board: Includes the crystal oscillator, counters, and timer control relays (start and enable).

A2 - EPROM Board: Includes the 2716 EPROM, latches, addressing circuits, and diagnostic circuits.



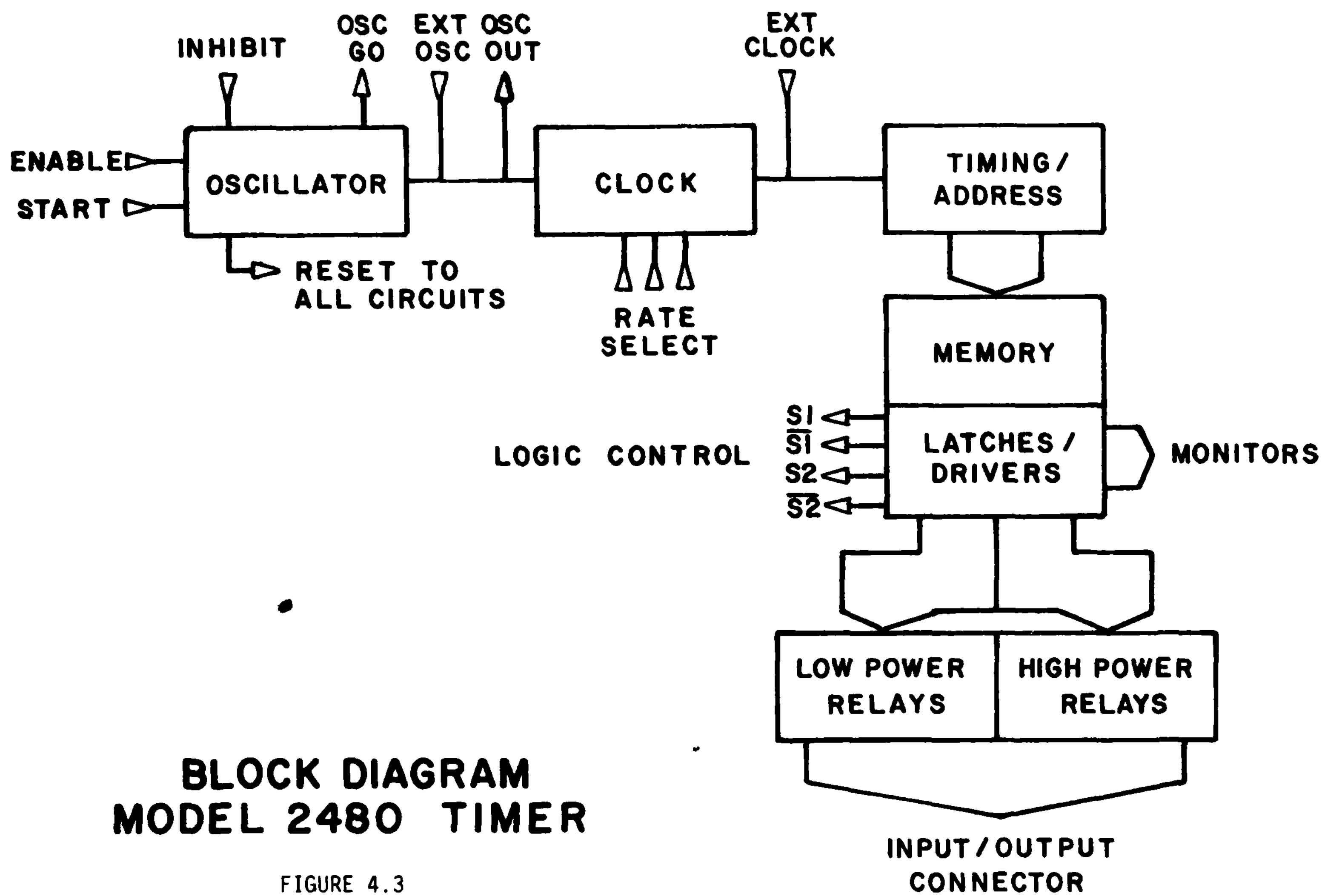
MODEL 2480 REDUNDANT TIMER

FIGURE 4.2

A3 - Relay Board: Has provisions for ten SPDT relays. Relay configuration is selected for the specific payload application.

A4 - Power Relay Board: Has provisions for eight DPDT relays. Relay configuration, including latching or non-latching option, is selected for the specific payload application. Provisions for GSE control of relays is also included.

Figure 4.3 illustrates the six (6) basic functions of a single timer. A stable, high frequency OSCILLATOR is used as a time base. Elapsed time is measured in pre-programmed increments generated by the CLOCK circuit. These increments are then used in TIMING/ADDRESS circuits to access the flight program at each increment transition. Required flight data is programmed into erasable programmable read only memory (EPROM), external to the timer. Data stored in MEMORY is held by the LATCHES until the next time increment and conditioned by the DRIVERS to operate the payload control relays. The LOW POWER RELAYS can switch up to one ampere at 28 volts. These single pole double throw (SPDT) relays are non-latching, but may be held on for any period in the flight program. The double pole double throw (DPDT) HIGH POWER RELAYS are used for power transfer and pyrotechnic activation and may be either latching or non-latching.



BLOCK DIAGRAM
MODEL 2480 TIMER

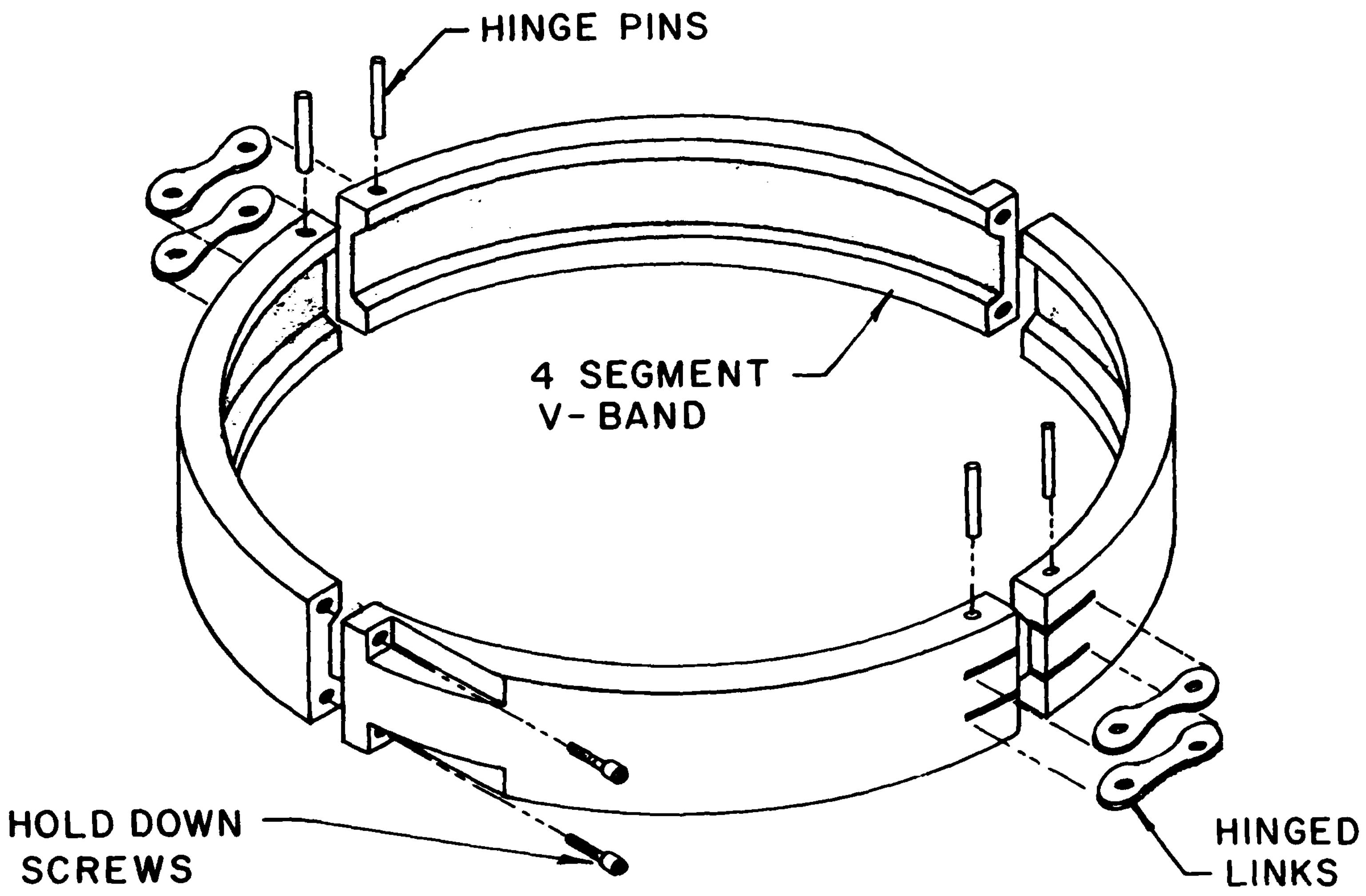
FIGURE 4.3

Qualification level vibration and shock tests were conducted with a prototype timer in August 1978. Redundant timers were then fabricated and checked in payloads A08.708-1 and A08.708-2. As reported in Section 2.4 the timers performed flawlessly during the launch of A08.708-1 at WSMR. Model 2480 timers were then flown successfully in payloads A10.802-1, A10.802-2, A18.805, A10.901-1, A30.072, A13.020, A13.030, A13.031.

A test unit, capable of testing the four component printed circuit boards individually or collectively, was designed and fabricated. In addition to control and monitor functions, the panel allows simulation of addresses, clock pulses, and relay circuits for analysis and confirmation of redundant operation.

4.4 MANACLE RING SEPARATION SYSTEM

Separation joint design problems encountered on payloads A13.030 and A13.031 led to the development of a high retention manacle ring separation system. The basic assembly is shown in Figure 4.4. Double 30 degree bevels are utilized on the four segment mechanism with a reinforced cross section and reinforced flanges. As indicated, hinged links and screw fastened flanges are provided alternately at 90 degree increments. Cutting either pair of hold down screws will release the "V" bands. The basic design can be used in many applications by adapting the cutter and varying the charge of the pyrotecnic device. In the A13.030/A13.031 payloads the cutter mechanism was positioned at a 45 degree angle to solve the problem inherent in separating a sealed joint. Both the aft vehicle separation and the forward nosecone release



MANACLE RING ASSEMBLY

FIGURE 4.4

used identical manacle rings on the above payloads.

Load tests of the manacle joint were conducted on the bending fixture at AFGL. The load capacity of the joint far exceeded the defined Taurus-Orion specifications. Separation tests were then conducted at Northeastern using the manacle joint test fixture. Single actuators were used for the first two tests, (a condition occurring only if one of the redundant firing circuits failed) then both actuators were fired simultaneously to simulate the anticipated flight condition. A clean separation occurred in all tests. Each of the four flight mechanisms in payloads A13.030 and A13.031 also successfully test fired using a single actuator and the flight sequencer.

4.5 IN-FLIGHT IGNITION SYSTEM

A system to provide in-flight ignition of second-stage rocket motors was designed and qualified during the contract period. The package is adaptable to 9, 12, and 14-inch diameter vehicles. Two independent electrical circuits, consisting of a nicad battery, a power transfer relay (safe/arm) and a mechanical timer were packaged along with an umbilical connector and a mechanical safe/arm connector. A control and monitor panel, including battery charging capabilities, was also developed. Second stage Orion motors used on payloads A13.020, A13.030 and A13.031 were successfully ignited with the in-flight modules.

5.0 <u>TRAVEL</u>

TABLE 5.1

F19628-76-C-0152

1 June 1976 to 31 April 1981

PROJECT	LAUNCH SITE	STAFF	TRIP DURATION
MSMP	WSMR	R. Morin	14- 16 Dec. 1976
MSMP	PSL	F. Bonanno	16 - 20 May 1977
A10.705-1	WSMR	R. Anderson	15 - 24 Sept. 1977
		F. Tracy	15 - 24 Sept. 1977
A24.609-1	PSL/WSMR	C. Sweeney	13 Oct. - 12 Nov. 1977
		H. Tweed	13 Oct. - 12 Nov. 1977
		R. Eng	16 Oct. - 12 Nov. 1977
		R. Morin	17 Oct. - 12 Nov. 1977
IC719.08-1	PFRR	R. Anderson	25 Oct. - 20 Nov. 1977
		R. Marks	24 Oct. - 20 Nov. 1977
		L. O'Connor	24 Oct. - 20 Nov. 1977
A04.602	WSMR	R. Anderson	4 - 13 Dec. 1977
		F. Tracy	4 - 13 Dec. 1977
IC.719-08-1	PFRR	R. Anderson	21 Feb. - 1 Mar. 1978
		R. Marks	21 Feb. - 1 Mar. 1978
		L. O'Connor	21 Feb. - 1 Mar. 1978
		F. Tracy	21 Feb. - 1 Mar. 1978
A24.609-2	WSMR	F. Bonanno	17 Aug. - 10 Sept. 1978
		H. Tweed	17 Aug. - 10 Sept. 1978
		R. Morin	22 Aug. - 9 Sept. 1978
		C. Sweeney	24 Aug. - 10 Sept. 1978
A08.708-1 A08.708-2	WSMR	R. Anderson	5 Sept. - 22 Sept. 1978
		M. Curley	5 Sept. - 17 Sept. 1978
		F. Tracy	5 Sept. - 22 Sept. 1978

TABLE 5.1 (continued)

F19628-76-C-0152

1 June 1976 to 31 April 1981

PROJECT	LAUNCH SITE	STAFF	TRIP DURATION
A10.708-1 A10.708-2	Red Lake, Ontario	R. Anderson R. Eng F. Tracy	8 Feb. - 2 Mar. 1979 8 Feb. - 1 Mar. 1979 8 Feb. - 1 Mar. 1979
A31.702	Phoenix, Arizona	L. O'Connor	23 Apr. - 27 Apr. 1979
A24.609-2	WSMR	F. Bonanno H. Tweed	30 Apr. - 4 May 1979 30 Apr. - 4 May 1979
MSMP Drop Test #1	EAFB	J. Harris	17 June - 3 July 1979
A18.805 Integration	Space Vector, California	R. Eng R. Morin F. Tracy	17 June - 28 June 1979 17 June - 28 June 1979 17 June - 28 June 1979
MSMP Drop Test #2	EAFB	H. Tweed	15 July - 20 July 1979
MSMP Drop Test #3 & 4	EAFB	H. Tweed	29 July - 9 Aug. 1979
A18.805	WSMR	R. Eng J. Harris R. Morin F. Tracy	29 July - 9 Aug. 1979 29 July - 9 Aug. 1979 30 July - 9 Aug. 1979 30 July - 15 Aug. 1979
A18.705-2	WSMR	R. Anderson C. Sweeney	2 Aug. - 15 Aug. 1979 6 Aug. - 15 Aug. 1979

TABLE 5.1 (continued)

F19628-76-C-0152

1 June 1976 to 31 April 1981

PROJECT	LAUNCH SITE	STAFF	TRIP DURATION
A24.609-2	WSMR	F. Bonanno	4 Sept. - 4 Oct. 1979
		H. Tweed	4 Sept. - 4 Oct. 1979
		J. Harris	10 Sept. - 4 Oct. 1979
		R. Morin	10 Sept. - 4 Oct. 1979
A10.901-1,-2	PFRR	R. Anderson	3 Aug. - 21 Aug. 1980
			12 Oct. - 25 Oct. 1980
		P. Martell	3 Aug. - 30 Aug. 1980
			28 Sept. - 16 Oct. 1980
		C. Sweeney	15 Sept. - 13 Oct. 1980
		F. Tracy	3 Aug. - 30 Aug. 1980
			15 Sept. - 27 Sept. 1980
			14 Oct. - 25 Oct. 1980
A30.072	PFRR	J. Harris	24 Apr. - 17 May 1980
		L. O'Connor	24 Apr. - 17 May 1980
A24.609-2	WSMR	F. Bonanno	27 Apr. - 23 May 1980
		C. Sweeney	27 Apr. - 23 May 1980
		R. Morin	5 May - 23 May 1980
		H. Tweed	5 May - 23 May 1980
A-30.072	PFRR	L. O'Connor	12 Jan. - 6 Feb. 1981

6.0 PERSONNEL

The following Northeastern University staff members have contributed to the work described in this report.

J. Spencer Rochefort, Co-principal Investigator from 1 May 1976 to 30 June 1977.

Lawrence O'Connor, Principal Investigator

Robert Anderson

Francis Bonanno

Jonathan Harris

Christian Hazard

Edward Leiblein

Richard H. Marks

Richard Morin

Roger Eng

Norman Poirier

Raimundas Sukys

Charles Sweeney

Willard Thorn

Frederick Tracy

Harry Tweed

7.0 REFERENCES

1. A Discussion of Six Sounding Rocket Payload Designs - Final Report, 15 Sept. 1964 to 31 March 1967, Contract AF19(628)-4361, Northeastern University.

2. Design of Sounding Rocket Payloads - Final Report, 1 April 1967 to 28 February 1970, Contract F19628-67-C-0223, Northeastern University.

3. Design of Sounding Rocket Payloads - Final Report, 1 March 1970 to 28 February 1973, Contract F19628-70-C-0194, Northeastern University.

4. Program Timer - Model 50, Scientific Report No. 3, June 1975, Contract F19628-76-C-0152, Richard L. Morin, Northeastern University. (AFCRL-TR-75-0328)

5. Design of Sounding Rocket Payloads - Final Report, 1 March 1973 to 31 May 1976, Contract F19628-73-C-0152, Northeastern University. (AFGL-TR-76-0139)

6. Quarterly Status Report No. 1, 1 May 1976 through 31 July 1976, Contract F19628-76-C-0152.

7. Quarterly Status Report No. 2, 1 August 1976 through 31 October 1976, Contract F19628-76-C-0152.

8. Quarterly Status Report No. 3, 1 November 1976 through 31 January 1977, Contract F19628-76-C-0152.

9. Quarterly Status Report No. 4, 1 February 1977 through 30 April 1977, Contract F19628-76-C-0152.

10. MSMP Timer Testing and Programming Instrument - Scientific Report No. 1, 1 May 1977, Contract F19628-76-C-0152, Northeastern University, Raimundas Sukys. (AFGL-TR-77-0206)

11. Quarterly Status Report No. 5, 1 May 1977 through 31 July 1977, Contract F19628-76-C-0152.

12. Quarterly Status Report No. 6, 1 August 1977 through 31 October 1977, Contract F19628-76-C-0152.

13. Quarterly Status Report No. 7, 1 November 1977 through 31 January 1978, Contract F19628-76-C-0152.

14. Quarterly Status Report No. 8, 1 February 1978 through 30 April 1978, Contract F19628-76-C-0152.

15. Quarterly Status Report No. 9, 1 May 1978 through 31 July 1978, Contract F19628-76-C-0152.

7.0 REFERENCES (cont.)

16. Motor Drive Systems for Sounding Rocket Payloads - Scientific Report No. 2, October 1978, Contract F19628-76-C-0152, Northeastern University, Richard L. Morin. (AFGL-TR-78-0252)

17. Quarterly Status Report No. 10, 1 August 1978 through 31 October 1978, Contract F19628-76-C-0152.

18. Quarterly Status Report No. 11, 1 November 1978 through 31 January 1979, Contract F19628-76-C-0152.

19. Quarterly Status Report No. 12, 1 February 1979 through 30 April 1979, Contract F19628-76-C-0152.

20. Quarterly Status Report No. 13, 1 May 1979 through 31 July 1979, Contract F19628-76-C-0152.

21. Quarterly Status Report No. 14, 1 August 1979 through 31 October 1979, Contract F19628-76-C-0152.

22. Command Control Consoles For Sounding Rocket Payloads - Scientific Report No. 3, December 1979, Contract F19628-76-C-0152, Northeastern University, Richard L. Morin. (AFGL-TR-80-0019)

23. Quarterly Status Report No. 15, 1 November 1979 through 31 January 1980, Contract F19628-76-C-0152.

24. Quarterly Status Report No. 16, 1 February 1980 through 30 April 1980, Contract F19628-76-C-0152.

25. Quarterly Status Report No. 17, 1 May 1980 through 31 July 1980, Contract F19628-76-C-0152.

26. Quarterly Status Report No. 18, 1 August 1980 through 31 October 1980, Contract F19628-76-C-0152.

27. Quarterly Status Report No. 19, 1 November 1980 through 31 January 1981, Contract F19628-76-C-0152.